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Study of Micronutrients and Macronutrients in Soils of Coastal and Gir Forest Region of Saurashtra, Gujarat

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ABSTRACT

An attempt has been made to investigate the availability of micronutrients and macronutrients in soil samples collected from selected places (Gir Somnath, Junagadh, Amreli, forest region and Diu, Dwarka, Jamnagar, Narara Island) of Saurashtra region, Gujarat. Soil samples were analyzed to the occurrence of available macronutrient (Organic Carbon, Nitrogen, Potassium, Phosphorus, Sulfur) and micronutrients (Iron, Zinc, Copper, Manganese) along with Electrical Conductivity (EC) and pH. Study of the correlation among macro and micronutrients was done. This correlation analysis found the Electrical conductivity and Sulfur showed a strong positive relationship (r = 0.878). Phosphorus and potassium show a strong relationship with each other (r = 0.759). Organic carbon is positively correlated with Phosphorus (r = 0.466), Sulfur (r = 0.448), Potassium (r = 0.391) and Copper (r=0.018).

Keywords Correlation analysis, Fertility, Macronutrient, Micronutrient, Soil.

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INTRODUCTION

Soil chemical properties are related to the nutrien-accessibility and growing conditions, biological properties in soil subsidize to soil aggregation,-structure and porousness, still as decomposition and mineralization. Several soil properties are inter connected with each other, it's trouble some to draw completely different lines of division wherever one kind of property directs the behavior of the soil. Therefore, kind and recognizing soil properties and their connections or correlation with each other is very important for creating wide-ranging choices relating to soil use (Paes *et al.* 2020). Soil surveys live a basic tool for deciding and searching for the basic soil characteristics of an area. They provide useful knowledge for soil nutrient accessibility. Soil may be a basic want of agriculture productivity and fertility. A soil analysis may be a principal issue to distinctive the provision of nutrient needed by crop fertility and better productivity on the idea of soil testing controlled the soil fertility by rehabilitating or utilization the offered nutrient content on the idea of crop demand (Frąc *et al*. 2018). A soil analysis may be a valuable tool for determines the inputs needed for economical and economic production. A correct soil check can facilitate make sure the application of enough chemical to satisfy the wants of the crop whereas taking advantage of the nutrients already ability within the soil. It will conjointly enable you to check lime needs and might be able to diagnose drawback areas. The principal demand for soil fertility

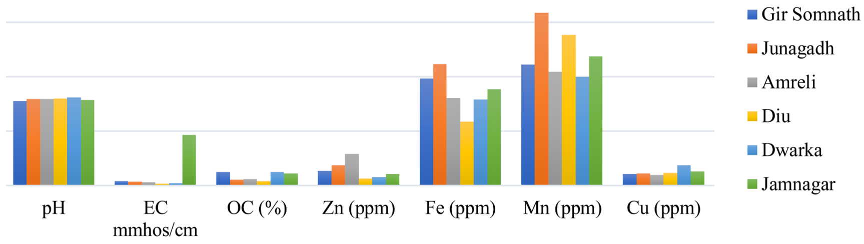

Fig. 1. Graphical representation of parameters pH, EC, OC, Zn, Fe, Mn and Cu at various districts of Saurashtra region.

is a macronutrient Organic Carbon (OC), Nitrogen (N), Potassium (K), Phosphorus (P) and Sulfur (S) and micronutrients Iron (Fe), Zinc (Zn), Copper (Cu) and Manganese (Mn)) (Rattan *et al.* 2009), other factors can also be affected like pH, electrical conductivity (EC), OC these are directly correlated to regulate the crop productivity and deficiency of those elements (Vijayakumar *et al.* 2011). A soil analysis will access the suitable quantity of small and macronutrients or deficiency of obtainable nutrient will recharge consistent with the necessity or growth of plant productivity. The Saurashtra region, Gujarat has a wide variation due to its topographic condition. The Saurashtra region of the Gujarat State includes Amreli district in the direction of the east, Junagadh district within the west, Jamnagar districts within the north, Dwarka within the North West and Gir-Somnath in the south of Saurashtra. Diu with the coastal region to the south of Gir-Somnath district. The region features a diversity varying from forest and coastal areas as well as wetlands. The objective of the study was to analyze different parameters of soil.

MATERIALS AND METHODS

Soil sampling **:** Soil samples were collected from thirty-five different places of districts Junagadh, Gir Somnath, Amreli, Diu, Dwarka and Jamnagar from Saurashtra region, Gujarat. Samples containing soil were collected from a depth of 10–30 cm during June 2019 to December 2019 into labelled sterile polythene packets packed and transferred to the laboratory for Chemical analysis. The soil samples were dried up and then sieved with the help of a 200-micron sieve for chemical analysis.

Analysis of soil samples **:** Soil pH was estimated by pH meter by preparing soil paste with distilled water (1:5 ratio) and Electrical Conduc-

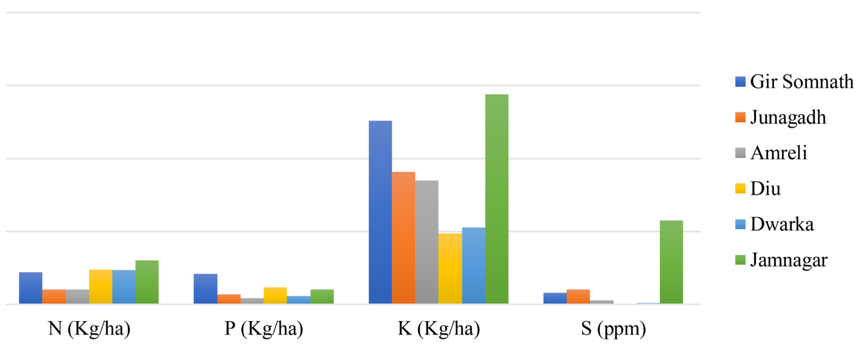

Fig. 2. Graphical representation of parameters N, P, K and S at various districts of Saurashtra region.

Table 1. Interpretation of micronutrients and macronutrients present in districts Gir Somnath, Junagadh and Amreli.

District Parameters		Gir Somnath Values	Interpretation	Junagadh Values	Interpretation	Values	Amreli Interpretation
pH	Mean	7.75	Slightly acid to	7.96		7.93	
					Moderately		Moderately
	Minimum	6.97	Moderately	7.90		7.85	
					alkaline		alkaline
	Maximum	8.11	alkaline	8.02		7.97	
EC	Mean	0.39	Slightly acid to	0.34		0.31	
mmhos/cm	Minimum	0.13	Moderately	0.19	Slightly saline	0.19	Slightly saline
	Maximum	0.90	alkaline	0.51		0.41	
	Mean	1.21	Low to High	0.53		0.59	Medium
					Low to		
OC (%)	Minimum	0.33	Low to Hight	0.36		0.51	
					Medium		
	Maximum	3.24		0.69		0.64	
	Mean	88.20		40.77		41.55	
N (kg/ha)	Minimum	31.36	Low	31.36	Low	18.82	
	Maximum	219.52		50.18		62.72	
	Mean	84.01		28.29		17.94	
					Low to		Low to
P (kg/ha)	Minimum	9.66	Low to High	24.84		5.52	
					Medium		Medium
	Maximum	763.14		31.74		30.36	
K (kg/ha)	Mean	503.16	Low to High	362.88	High	339.36	
	Minimum	53.76		268.80		282.24	High
	Maximum	1868.16		456.96		456.96	
S (ppm)	Mean	32.16		41.44		11.29	
	Minimum	2.38	Low to High	2.72	Low to High	4.42	Low to High
	Maximum	221.77		80.15		23.09	
Zn (ppm)	Mean	1.32		1.83		2.88	
	Minimum	0.60	Medium to High	1.56		0.92	Medium to High
	Maximum	3.20		2.09		8.00	
Fe (ppm)	Mean	9.84		11.15		8.06	
	Minimum	3.98	Low to High	10.00	High	1.80	Low to High
	Maximum	13.09		12.30		11.05	
Mn (ppm)	Mean	11.11		15.90		10.45	Medium to High
	Minimum	2.24	Low to High	15.80	High	8.06	
	Maximum	16.60		16.00		16.42	
Cu (ppm)	Mean	1.03		1.10		0.94	
	Minimum	0.46	High	0.90	High	0.14	High
	Maximum	1.44		1.30		1.62	

tivity (EC) was estimated by an EC meter (1 : 2 ratio) (Basu 2011). Organic Carbon (OC) in the soil samples was analyzed using wet digestion method (Ramamoorthi and Meena 2018). Available nitrogen (N) was analyzed in the soil samples using alkaline permanganate method (Shahane *et al*. 2018). Available Phosphorus was determined using Bray's method (Das *et al.* 2017). Available Potassium (K) was measured by Flame photometer using neutral normal ammonium acetate as an extractant following the method given by Jackson (Prajapati *et al.* 2018). Available Sulfur (S) was determined using the turbid ometric method (Singh *et al.* 2017). Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu)

Table 2. Interpretation of micronutrients and macronutrients present in districts Dwarka, Diu and Jamnagar.

Parameters	District Minimum	Values	Dwarka Interception	Values	Diu Interception	Values	Jamnagar Interception
	Mean	8.10		8.00		7.83	
			Moderately		Moderately		Moderately
							acid to strongly
Minimum	8.04		7.93		5.94		alkaline
			alkaline		alkaline		
	Maximum	8.17		8.07		8.59	
	Mean	0.18		0.16		4.63	
							Slightly saline
							to highly
	Minimum	0.17	Slightly saline	0.12	Slightly saline	0.13	
EC mmhos/cm							Saline
	Mean	1.26		0.36	Low	1.10	
OC (%)			Low to High		Low		Low to High
	Minimum	0.48		0.34		0.34	
	Maximum	2.14		0.38		3.45	
	Mean	94.08		95.65		121.41	
N (kg/ha)	Minimum	56.45	Low	62.72	Low	81.54	Low
	Maximum	125.44		128.58		225.79	
	Mean	23.12	Low to Medium	46.92	Medium	41.60	
P (kg/ha)	Minimum	16.56		28.98		1.38	Low to High
	Maximum	31.74		64.86		154.56	
	Mean	211.68		194.88		576.00	
K (kg/ha)	Minimum	188.16	Medium to High	80.64	Low to High	13.44	Low to High
	Maximum	228.48		309.12		1384.32	
	Mean	4.59		2.04		230.65	
S (ppm)	Minimum	1.02	Low	1.7	Low	3.74	Low to High
	Maximum	8.83		2.38		542.03	
	Mean	0.76		0.61		1.02	
Zn (ppm)	Minimum	0.43	Low to High	0.5	Medium to High	0.56	Low to High
	Maximum	1.02		0.72		1.43	
Fe (ppm)	Mean	7.90	Low to High	5.88	Low to Medium	8.82	Medium to
	Minimum	4.80		4.96		5.28	High
	Maximum	11.09		6.8		12.20	
Mn (ppm)	Mean	9.96	High	13.86	Medium to High	11.85	Medium to
	Minimum	7.42		13.3		8.76	High
	Maximum	11.60		14.42		16.25	
Cu (ppm)	Mean	1.83	High	1.155	High	1.29	High
	Minimum	1.24		0.9		0.74	
	Maximum	2.48		1.41		2.33	

elements analysis was done with the use of Atomic Absorption Spectrophotometer using DTPA extractable micronutrient elements as proposed by Lindsay and Norvell (1978) (Choudhury *et al.* 2019, Lindsay and Norvell 1978). Interpretation of all the physical and chemical properties of soil was done according to Methods Manual Soil Testing in India (Basu 2011).

Tools and techniques **:** Descriptive statistical analysis and Pearson's correlation analysis were used to analyze soil samples data. Variables employed for analysis in this study include Organic Carbon (OC), available nitrogen (N), potassium (K), phosphorus (P), Electrical Conductivity (EC), pH, sulfur (S), Manganese (Mn), Zinc (Zn), Iron (Fe) and Copper (Cu). Descriptive statistics followed by correlation test was performed using XLSTAT for Windows (Fahmy 2016).

RESULTS AND DISCUSSION

pH **:** The measure of soil pH may be a vital param-

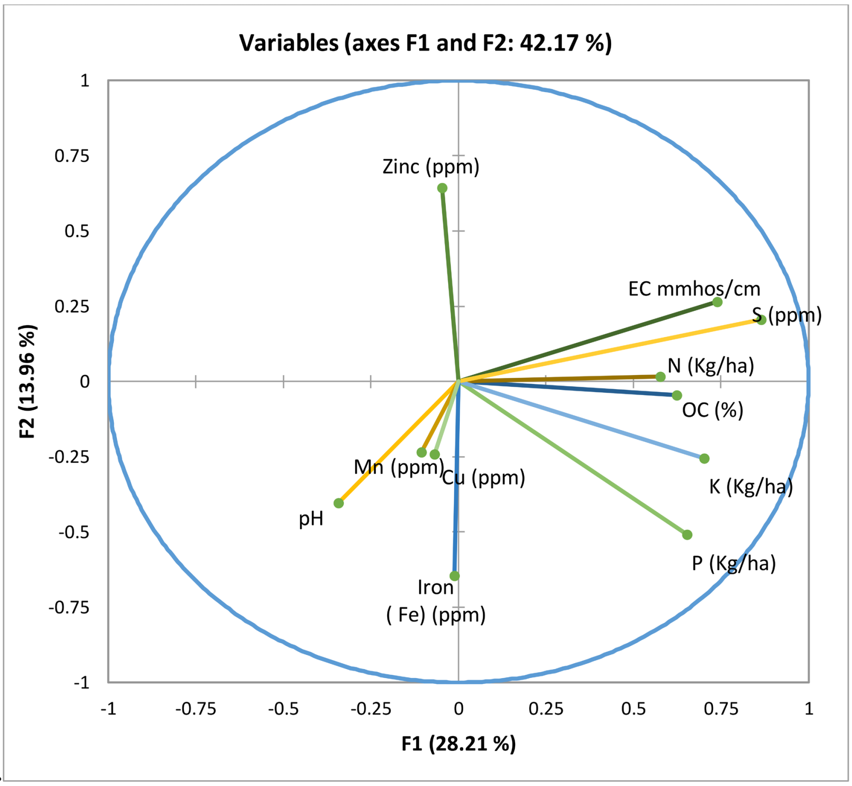

Fig. 3. Correlation circular biplot of all parameters.

eter which aids in the analysis of chemical properties of the soil because it measures proton concentration within the soil to point it's an acidic and alkaline environment of the soil. The pH of the samples was found to be in between 5.94 and 8.59 representing the presence of a spread of soils that are slightly acid to strongly alkaline (Tables 1 and 2).

Electrical conductivity : The measurement of current carrying capacity, gives an idea of the soluble

Table 3. Descriptive Statistics of parameters pH, Electrical Conductivity, Organic Carbon (OC), Available Nitrogen (N), Phosphorus (P) and Potassium (K).

Statistics	pH	EC mmhos/ cm	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Minimum	5.94	0.12	0.33	18.82	1.38	13.44
Maximum	8.59	13.04	3.45	225.79	763.14	1868.16
Mean	7.86	1.18	1.04	87.90	55.71	440.06
Variance (n-1)	0.19	9.10	0.68	2722.14	16352.20	151427.73
Standard deviation (n-1)	0.43	3.02	0.82	52.17	127.88	389.14
Variation coefficient	0.05	2.52	0.78	0.59	2.26	0.87
Skewness (Pearson)	-2.79	3.47	1.51	1.23	5.06	2.09
Kurtosis (Pearson)	9.98	10.54	1.45	0.98	25.39	4.42
Standard error of the mean	0.07	0.51	0.14	8.82	21.61	65.78

Table 4. Descriptive Statistics of parameters Sulfur (S), Zinc (Zn), Iron (Fe), Manganese (Mn) and Copper (Cu).

Statistics	S (ppm)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Minimum	1.02	0.43	1.80	2.24	0.14
Maximum	542.03	8.00	13.09	16.60	2.48
Mean	65.13	1.36	9.06	11.48	1.17
Variance (n-1)	21079.05	1.60	8.35	14.07	0.25
Standard deviation (n-1)	145.19	1.27	2.89	3.75	0.50
Variation coefficient	2.20	0.91	0.31	0.32	0.42
Skewness (Pearson)	2.58	4.34	-0.57	-0.53	0.69
Kurtosis (Pearson)	5.18	20.09	-0.49	-0.23	0.87
Standard error of the mean	24.54	0.21	0.49	0.63	0.08

salts which are present within the soil. It plays an important role in the salinity of soils. Lesser the EC value low is going to be the salinity value of soil and the other way around. Conductivity was found to be low at most of the sites indicating low salinity, in case of Jamnagar district electrical conductivity, was found to higher indicating high saline environment (Tables 1 and 2). The electrical conductivity of soil water is a good indicator for absorbing the number of nutrients available for plants was observed (Chaudhari *et al.* 2014). The electrical conductivity of soil is inclined by many factors, electrical conductivities with higher values are usually related with clay-rich soil and low conductivities are generally linked with sandy and gravelly soils (Valente *et al.* 2012). This is due to the physical properties of the particles by which soil is made up of. Various factors affect the soil electrical conductivity such as pore continuity, cation exchange capacity, water content, salinity level, depth and temperature.

Organic carbon (OC) : Organic matter within the soil is implied within the definition of soil, which identifies fertility grade of the soil, as a remarkable feature unique soil from the parent rock or other non-fertile soils. Soil organic matter is a substitute for soil carbon and is measured as a consideration of overall soil health (Laishram *et al.* 2012). Organic matter increases the soil fertility nutrient status and controls erosion and excess of the soil and water, besides it's an important determinant of improved moisture content, soil structure and nutrient condition of the soil (Wagg *et al*. 2014). The percentage of organic carbon (OC) ranged from 0.3 to 3.45 in the study area (Tables 1 and 2). Depending upon the organic carbon content (OC %), the quality of soil was found to be low to high. Soils with low carbon are due to good aeration which escalation the oxidation of organic matter present in the soil.

Available nitrogen **:** Available Nitrogen within the soil is one among the parameter for plant development. Nitrogen is essential in large amounts and must be further supplemented to the soil to evade deficiency (Pulito *et al.* 2015). Nitrogen generally comes by the use of fertilizer application and also from the air by biological means Nitrogen is absorbed by the plants in the nitrates form under aerobic conditions and as ammonium ions during anaerobic conditions. The percentage of available nitrogen was found in a range of 18.82 kg/ha to 225.79 kg/ha (Tables 1 and 2). Nitrogen content was found to be low in all the districts.

Phosphorus **:** Phosphorus is one of the macronutrients available in the biological systems, which constitutes more than 1% of the dry organic weight. It is one of the most limiting factors often affecting plant growth, which exists in the soil in both inorganic and organic form (Oviasogie and Uzoekwe 2011). Potassium is used by plants in higher quantities as compared to other mineral elements except for nitrogen. The phosphorus (kg/ha) was found in a range of 5.52 to 763.14 kg/ha (1 and 2). Phosphorus content was found to be low to high. Phosphorus was found too high in districts Gir Somnath and Jamnagar.

Potassium (K) **:** Succeeding to nitrogen (N) and

Table 5. Matrix correlations among different soil properties in tabular form.

	pH	EC mm-hos/cm	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (ppm)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
pH	1.000										
EC mmhos/cm	-0.111	1.000									
OC (%)	-0.517	0.181	1.000								
N (kg/ha)	-0.334	0.295	0.441	1.000							
P (kg/ha)	0.108	0.132	0.466	0.441	1.000						
K (kg/ha)	0.130	0.542	0.391	0.210	0.759	1.000					
S (ppm)	-0.375	0.878	0.448	0.514	0.278	0.486	1.000				
Zn (ppm)	-0.082	-0.045	0.045	-0.191	-0.058	-0.002	-0.025	1.000			
Fe (ppm)	-0.013	-0.179	0.173	-0.170	0.148	0.044	-0.025	-0.242	1.000		
Mn (ppm)	0.226	-0.062	-0.121	-0.107	0.010	-0.053	-0.031	-0.122	0.235	1.000	
Cu (ppm)	0.073	-0.099	0.018	0.064	-0.073	-0.109	-0.048	-0.503	-0.039	0.006	1.000

phosphorus (P), potassium (K) is an important essential element in inducing plant development and production throughout the world. It also reduces lodging, imparts disease resistance and increases the quality and shelf life of plant produce (Naidu *et al.* 2011). Potassium is an activator for dozens of enzymes responsible for plant process. The Potassium (K) (kg/ha) values varied from 13.44 to 1868.16 kg/ha (Tables 1 and 2). Potassium in soil samples ranged to be high in most of the districts.

Sulfur **:** Sulfur is one of the secondary nutrients of plants. Plants absorb sulfur in the sulfate form. Sulfur is a macronutrient for proteins and assistance in the development of chlorophyll and root development (Tairo and Ndakidemi 2013). Plants having a high concentration of sulfur grow leaves which are dark green and widespread root system. The concentration of sulfur in the soil samples was found to be in a range of 1.02 to 221.77 ppm (Tables 1 and 2). The high amount of sulfur was found in districts except Diu and Dwarka.

Zinc (ppm) **:** Zinc (Zn ppm) plays a critical role in the development of chlorophyll in leaf and directly related to the higher amount of leaves chlorophyll (Tarafdar *et al.* 2014). The absence or limited amount of Zn growth is affected to a lower amount of formation of, buds fall off and seed development. Zinc content in the soil samples was found to be in a range of 0.43 to 8.0 ppm (Tables 1 and 2).

Iron **:** Iron does not play a role directly for the formation in chlorophyll, the deficit has shown itself in chlorosis, yellowness or whitening of leaves. The amount of iron ions plays a critical role in the oxidation process in foliage cells. When iron is not absorbed in sufficient quantity, the growth of plants parts (leaves, shoot and roots) and seed and fruit development affected as a sign of reduced photosynthetic activity in the plant (Radzki *et al.* 2013). Higher liming can result in iron deficiency. Severe deficiency results in chlorosis and leaves turn white and yellow ultimately leaf loss. Iron content in the soil samples was found to be in a range of 1.8 to 13.09 ppm (Tables 1 and 2).

Manganese **:** Manganese is a component of the formation and Synthesis of chlorophyll. The insufficiency or lack of manganese, carbohydrate production is disturbed, causing growth, a decrease in the content to reproduce. The limited supply of manganese can be absorbed by leaves and roots of plants have much less of sugars than those which can absorb sufficient quantity of manganese (Dotaniya and Meena 2015). Manganese, may be in connotation with iron, is essential of certain respiratory enzymes and certain enzymes liable for protein synthesis from the amino acids in the leaves. The manganese content in the soil analysis was found to be in the range of 2.24 to 16.60 ppm (Tables 1 and 2).

Copper **:** The chloroplasts are present in plant leaves, some of the enzymes which are related to the Redox potential reaction. The copper play vital for this enzyme activity. Thus, copper also plays a function for the plant in photosynthetic reaction. The copper contents are found in the soil samples was to be in a range of 1.02 to 221.77 ppm (Tables 1 and 2). Copper content was found to be high in all districts.

Descriptive statistics

Soil parameters and statistics of soil analysis are given in Tables 3 and 4. Statistical investigation of correlation was completed by using the Pearson correlation method as shown in Table 5. Parameters organic carbon, nitrogen, potassium, iron, manganese and copper are normally distributed based on statistical analysis. Rest of the parameters are not normally distributed. In case of soil analysis normal distribution was not observed in cases of geology (Cerri and Magalhães 2012).

Correlation among soil parameters

The correlation among the selected parameters is given in Table 5. Correlation of pH with electrical conductivity, OC, N, S, Zn, and Fe was found to be negative and with that of phosphorus, potassium, manganese, copper was found to be positive. Electrical conductivity was negatively correlated with zinc, iron, manganese and copper, positively correlated with organic carbon, nitrogen, phosphorus, potassium and sulfur. Electrical conductivity and sulfur showed a strong positive relationship ($r = 0.878$). Phosphorus and potassium show a strong relationship with each other ($r = 0.759$) similar type of observation was made by (Pattani *et al.* 2016). Organic carbon showed a positive strong relationship with phosphorus, sulfur, potassium and nitrogen. Nitrogen showed a positive correlation with phosphorus, potassium, sulfur and copper.

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