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# Delineation of Soil Physical and Chemical Properties of Mahisagar District of Gujarat, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The successful implementation of sustainable agriculture practices relies on maintaining a favorable physical and chemical environment in the soil. This study aimed to assess the soil properties of Mahisagar district in Gujarat, focusing on both physical and chemical aspects. A total of 180 surface soil samples (0-15 cm depth) were collected from cultivated fields in six talukas during April-May 2018. Key indicators, including bulk density, particle density, porosity, moisture-holding capacity (MWHC), electrical conductivity (EC2.5), pH2.5, free lime, organic carbon, and cation exchange capacity (CEC), were analyzed to provide a comprehensive understanding of the soil's characteristics. The results indicated that mean bulk density and particle density value of the soils of

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Mahisagar district was 1.32 and 2.53 Mg $m^{-3}$ respectively, while porosity with a mean value of 47.97 per cent. The overall range of MWHC was with a mean value of 45.97 per cent. The soils of Mahisagar district were high in organic carbon content and non-calcareous in nature with alkaline in reaction. The mean $EC_{2.5}$ value in the soils of Mahisagar district was (0.38 dS $m^{-1}$). The mean CEC value was 24.47 cmol ($p^+$) $kg^{-1}$. among the exchangeable cations $Ca^{++}$ and $Mg^{++}$ was dominance in soil, while water soluble ions $Cl^-$ and $Mg^{++}$ were found in higher proportion in Mahisagar district of Gujarat.

*Keywords: Soil survey; soil physical properties; soil chemical properties; soil fertility.*

## 1. INTRODUCTION

Life supporting system of a country and the socio-economic development of its people depends upon proper use of soil. To meet the requirements of food, fiber, fuel, fruits for the increasing population, farm land development is often extended even to the areas unsuitable for agriculture with the shrinking of land for agriculture. The existing cultivated area is subjected to greater burdens in many cases. Success in agriculture depends on the land quality and soil characteristics. At this juncture, our efforts for increasing productivity should aim at the optimum utilization of natural resources viz., water and climate without impairing the environment.

Soil survey provides useful information for proper planning of soil and water management practices, which plays important role in augmenting crop production. Among the natural resources, soil is available finite, non-elastic and non-renewable asset.

It is estimated that about 8.087 million hectares of land in India are affected by the problem of salinity and sodicity [1,2]. In Gujarat, about 2.22 million hectares of land is affected due to salinity and sodicity and extensively distributed both on the coastal and inland areas [3]. The major part of Bhal tract adjoining the Gulf of Cambay in Saurashtra is salt affected and areas under Ukai-Kankarapar command are also salt affected. Coastal saline soils are spread over the districts of Surat, Valsad, Bharuch, Kheda, Ahmedabad, Bhavnagar, Surendranagar, Amreli, Rajkot, Jamnagar, Junagadh and Kuchchh including newly formed Gir Somnath and Dev Bhumi Dwarka districts of Gujarat. A good crop yield is the result of integrated effect of the prevailing weather conditions of a particular area, genetic potentiality of plant, soil and crop management practices and availability as well as reserve of the plant nutrients.

Soil fertility provides the information for highlighting the nutrient needs. Obviously, a soil fertility status for a particular area can be proved highly beneficial in guiding the farmers, manufactures and planner in ascertaining the requirement of various fertilizers in a season / year and making projections for increasing requirement based on cropping pattern and intensity. Thus, present survey work was planned to conduct systematic soil survey and find out the soil physical and chemical properties of Mahisagar district of Gujarat.

## 2. MATERIALS AND METHODS

Surface (0-15 cm) soil samples collected from the cultivated fields of the farmer's were allowed to dry completely in the laboratory. The air-dried samples were grounded carefully with a wooden mortar and pestle to break soil lumps. These grounded soil samples were passed through 2 mm sieve and then stored in polyethylene sample bags with proper labels. working samples were drawn from these bulk samples. These samples were used for physical as well as chemical properties of soil. The bulk density, particle density and porosity of soil samples were determined as per the method described by Richards [4], whereas the maximum water holding capacity by Chopra and Kanwar (1991). For the determination of exchangeable cations ($Na^+$, $K^+$, $Ca^{++}$ and $Mg^{++}$) neutral normal ammonium acetate ($NH_4OAC$) was used as per the methods described by Richard [4]. For the analysis of water-soluble cations and anions in surface soil samples, we use soil-water ratios (1:2.5). The $EC_{2.5}$, $pH_{2.5}$, water soluble cations *i.e.* $Na^+$, $K^+$, $Ca^{++}$ and $Mg^{++}$, as well as anions *i.e.* $Cl^-$, $CO_3^{--}$, $HCO_3^-$ and $SO_4^{--}$ were determined as per the methods described by Richard [4]. The soil organic carbon (OC) was estimated by wet digestion method of Walkley and Black [5]. While cation exchange capacity (CEC) was determined by Ammonium acetate method of Chapman [6] and Free $CaCO_3$ content was estimated by Rapid acid neutrali-zation method by Piper [7].

## 3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

### 3.1 Bulk Density

The mean bulk density value of the soils of Mahisagar district was 1.32 Mg $m^{-3}$ and it was ranged from 1.23 to 1.45 Mg $m^{-3}$. The lowest bulk density value of 1.23 Mg $m^{-3}$ was recorded in a sample collected from Lunawada and Kadana talukas. The highest bulk density value of 1.45 Mg $m^{-3}$ was recorded in the samples collected from Virpur taluka. These results are in conformity with an earlier report of Ogunwale and Isa [8], Rao et al. [9], Savalia et al. [10], Shirgire [11] and Singh and Sharma [12].

### 3.2 Particles Density

The mean particle density value of the soils of Mahisagar district was 2.53 Mg $m^{-3}$ and it was ranged widely from 2.32 to 2.78 Mg $m^{-3}$. The lowest particle density value of 2.32 Mg $m^{-3}$ was recorded in a sample collected from Balasinor taluka. The highest value of 2.78 Mg $m^{-3}$ was recorded in the samples collected from Virpur taluka. Similar result was obtained by Ogunwale and Isa [8], Savalia et al. [10], Ram et al. [13] and Shirgire [11].

### 3.3 Porosity

The porosity of soils of Mahisagar district ranged from 37.07 to 51.50per cent with a mean value of 47.97 per cent. The lowest (37.07 %) and highest (51.50 %) pore space value were recorded in a sample collected from Kadana and Khanpur respectively. These finding are parallel to those of Savalia and Gundaliya [10] and Ram et al. [13].

### 3.4 MWHC

The overall range of MWHC was 29.25 to 64.23 per cent with a mean value of 45.97 per cent. The lowest MWHC value of 29.25 per cent was recorded in a sample collected from Virpur taluka. The highest MWHC value of 64.23 per cent was recorded in the sample collected from Lunawada taluka. Comparable results were reported for Southern Saurashtra [14], for Chittor district of Andhra Pradesh (Rao et al., 2010) and for Jamnagar district [11].

### 3.5 Electrical Conductivity ($EC_{2.5}$)

The mean $EC_{2.5}$ value in the soils of Mahisagar district was 0.38 dS $m^{-1}$ and ranged from 0.11 to 2.1 dS $m^{-1}$. Soils of Khanpur (0.49 dS $m^{-1}$) and Santrampur (0.44 dS $m^{-1}$) talukas have higher $EC_{2.5}$ mean values. Parallel results were also obtained for Girnar topo sequence by Gandhi [15], for Patan district by Patel et al. [16], Reddy and Naidu [17] for Kapada district of Andhra Pradesh and Wagh et al. [18] for of Nagpur district of Maharashtra.

### 3.6 Soil Reaction ($pH_{2.5}$)

In general, the soils of this district were alkaline (pH value ranging from 6.29 to 8.76 with a mean value of (7.60) in reaction. The lowest pH value of 6.29 was recorded in a soil sample collected from Santrampur taluka. The highest value of 8.76 was recorded in the sample collected from Lunawada taluka. Pedapuluguvaripalem village of Guntur district by Nandy et al. [19], for Patan district by Patel et al. [16], Reddy and Naidu [17] for Kapada district of Andhra Pradesh and Wagh et al. [18] for of Nagpur district of Maharashtra.

The overall free lime content was ranging from 3.22 to 6.75 with a mean value of 4.28 per cent. The highest mean value of 4.37 per cent was recorded in Balasinor taluka and the lowest mean value of 4.12 per cent was obtained in Kadana taluka indicate non calcareous soils prevailing in entire district. Similar results were observed for Girnar topo sequence by Gandhi [15] and Latur district by Gajare et al. [20].

### 3.7 Organic Carbon

The soils of Mahisagar district were high in organic carbon content. It was ranging from 0.12 to 1.77 per cent with a mean value of 0.82 per cent. Highest O.C mean value (0.96%) reported in Santrampur taluka and lowest mean value (0.64%) of O.C reported in Lunawada taluka. The soils of Mahisagar district were high in organic carbon content. It was ranging from 0.12 to 1.77 per cent with a mean value of 0.82 per cent. Highest O.C mean value (0.96%) reported in Santrampur taluka and lowest mean value (0.64%) of O.C reported in Lunawada taluka.

### 3.8 Cation Exchange Capacity (CEC)

The overall range of CEC was 13.78 to 46.93 cmol ($p^+$) $kg^{-1}$ with mean a value of 24.47 cmol ($p^+$) $kg^{-1}$. The lowest CEC value 13.78 cmol ($p^+$) $kg^{-1}$ was reported in Kadana taluka. The highest

**Table 1. Taluka wise range and mean values for physical properties of soil of Mahisagar district**

| Name of talukas | Bulk density ($Mg\ m^{-3}$) | | Particles density | | Porosity (%) | | MWHC | |
|---|---|---|---|---|---|---|---|---|
| | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value |
| Balasinor | 1.27-1.37 | 1.31 | 2.32-2.63 | 2.51 | 45.04-49.62 | 47.76 | 40.0-62.10 | 48.41 |
| Lunawada | 1.23-1.40 | 1.31 | 2.40-2.69 | 2.52 | 44.63-49.81 | 47.98 | 36.0-64.23 | 47.22 |
| Kadana | 1.23-1.40 | 1.33 | 2.36-2.68 | 2.53 | 37.07-50.19 | 47.57 | 37.75-52.00 | 44.01 |
| Khanpur | 1.26-1.40 | 1.32 | 2.35-2.74 | 2.51 | 41.83-51.50 | 46.79 | 34.67-53.67 | 45.18 |
| Virpur | 1.25-1.45 | 1.32 | 2.39-2.78 | 2.55 | 44.35-50.37 | 48.07 | 29.25-58.0 | 45.08 |
| Santrampur | 1.24-1.40 | 1.32 | 2.43-2.67 | 2.53 | 43.62-49.81 | 47.91 | 32.98-55.67 | 46.94 |

**Table 2. Taluka wise range and mean values for chemical properties of soil of Mahisagar District Free $CaCO_3$**

| Name of taluka | $EC_{2.5}$ ($dS\ m^{-1}$) | | $pH_{2.5}$ | | $CaCO_3$ (%) | | O.C. | | CEC $cmol\ (p^+)\ kg^1$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value |
| Balasinor | 0.13-1.16 | 0.33 | 7.15-8.47 | 7.70 | 3.22-6.25 | 4.37 | 0.25-1.38 | 0.80 | 1.54-34.2 | 23.80 |
| Lunawada | 0.13-1.38 | 0.34 | 6.33-8.76 | 7.78 | 3.24-5.75 | 4.29 | 0.27-1.07 | 0.64 | 16.67-36.03 | 25.15 |
| Kadana | 0.11-0.87 | 0.35 | 6.31-8.22 | 7.41 | 3.25-5.29 | 4.12 | 0.1-1.44 | 0.83 | 13.78-34.54 | 23.80 |
| Khanpur | 0.15-2.1 | 0.49 | 6.55-8.3 | 7.60 | 3.25-6.22 | 4.25 | 0.31-1.77 | 0.88 | 15.18-46.93 | 25.85 |
| Virpur | 0.15-0.75 | 0.34 | 6.65-8.73 | 7.58 | 3.23-6.75 | 4.36 | 0.12-1.30 | 0.75 | 14.18-31.31 | 24.12 |
| Santrampur | 0.16-1.64 | 0.44 | 6.29-8.75 | 7.55 | 3.25-6.64 | 4.30 | 0.96-1.36 | 0.96 | 14.95-40.5 | 24.13 |

**Table 3. Taluka wise range and mean values of exchangeable cations in soils of Mahisagar District**

| Name of taluka | Exchangeable cations in $cmol\ (p^+)\ kg^{-1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ca^{++}$ | | $Mg^{++}$ | | $Na^+$ | | $K^+$ | |
| | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value |
| Balasinor | 2.0-7.2 | 4.67 | 2.9-15.3 | 8.43 | 0.63-4.98 | 2..62 | 0.04-0.46 | 0.24 |
| Lunawada | 3.0-10.8 | 5.74 | 5.0-19.6 | 10.53. | 0.58-5.69 | 2.81 | 0.06-1.0 | 0.28 |
| Kadana | 2.7-14.3 | 6..16 | 5.2-15.3 | 10.0 | 0.78-6.34 | 2.68 | 0.06-0.72 | 0.21 |
| Khanpur | 2.3-24.7 | 7.2 | 4.2-21.2 | 8.51 | 0.67-5.69 | 2.66 | 0.08-0.63 | 0.20 |
| Virpur | 2.8-15.5 | 6.0 | 4.2-14.5 | 9.60 | 0.82-4.96 | 2.79 | 0.07-0.45 | 0.18 |
| Santrampur | 2.7-13.5 | 5.45 | 1.3-21.7 | 9.51 | 0.69-0.44 | 2.67 | 0.07-0.69 | 0.22 |

**Table 4. Taluka wise range and mean values of water-soluble cations in soils of Mahisagar district**

| Name of taluka | Water soluble cations in me $L^{-1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ca^{++}$ | | $Mg^{++}$ | | $Na^{+}$ | | $K^{+}$ | |
| | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value |
| Balasinor | 0.3-4.0 | 0.94 | 0.50-4.60 | 1.69 | 0.30-2.43 | 0.66 | 0.03-0.19 | 0.08 |
| Lunawada | 0.30-1.80 | 0.80 | 0.40-2.20 | 1.32 | 0.26-2.11 | 0.72 | 0.04-0.20 | 0.11 |
| Kadana | 0.30-2.40 | 0.98 | 0.50-2.40 | 1.53 | 0.11-1.68 | 0.63 | 0.04-0.17 | 0.09 |
| Khanpur | 0.30-2.0 | 1.13 | 0.40-3.0 | 1.66 | 0.44-2.53 | 0.84 | 0.04-0.21 | 0.10 |
| Virpur | 0.30-2.10 | 0.84 | 0.50-2.30 | 1.46 | 0.47-1.60 | 0.70 | 0.03-0.18 | 0.08 |
| Santrampur | 0.40-2.60 | 1.08 | 0.50-3.70 | 1.72 | 0.53-1.92 | 0.77 | 0.05-0.17 | 0.10 |

CEC value 46.93 cmol ($p^+$) $kg^{-1}$ found in Khanpur taluka. Same result was obtained for soils of Gantur of Andra Pradesh district by Nandy *et. at.,* [19] and Girnar toposequence by Gandhi [15].

The overall range and mean values (given in bracket) of 2.0-24.7 (5.87) of $Ca^{++}$, 1.30-21.7 (9.51) of $Mg^{++}$, 0.58-6.34 (2.70) of $Na^+$ and 0.04-1.0 (0.22) of $K^+$ cmol($p^+$) $kg^{-1}$ were recorded in entire district. In the soils of Khanpur taluka, mean $Ca^{+2}$ content (7.20 cmol($p^+$) $kg^{-1}$) was highest. As far as, the exchangeable $Na^+$ content in soil is concerned, Lunawada taluka registered the highest mean value of 2.81 cmol ($p^+$) $kg^{-1}$. In case of $Mg^{++}$ and $K^+$, highest mean values were found in the soils of Lunawada Taluka.

### 3.9 Water Soluble Cations

The overall range values of $Ca^{++}$, $Mg^{++}$, $Na^+$ and $K^+$ were 0.30-4.0, 0.40-4.60, 0.11-2.53 and 0.03-0.21 me $L^{-1}$, respectively were recorded in the soils of Mahisagar district (Table 4). The highest mean values of $Ca^{++}$ and $Mg^{++}$ were found in soils of Khanpur and Balasinor talukas while highest mean value of $Na^+$ was found in soils of Khanpur taluka. The lowest mean values of $Ca^{++}$ and $Mg^{++}$ were found in Lunawada taluka and lowest $Na^+$ mean value found in kadana taluka, respectively. This finding is in concurrence with the findings of Polara et al*.* [21], Kabaria and Polara [22] for soils of Amreli district, Polara et al*.* [23] for North-West Agroclimatic Zone of Gujarat and Marsonia et al*.* [24] for Porbandar district.

### 3.10 Water Soluble Anions

In case of anions, the highest overall mean value of 4.41 me $L^{-1}$ was recorded for $Cl^-$ and it was followed by $HCO_3^-$ (3.2 me $l^{-1}$) and $SO_4^-$ (0.35 me $L^{-1}$), while $CO3^-$ was not found in any collected soil sample of Mahisagar district (Table 5). Since the content of chloride and bicarbonate is considerably high, the type of salinization prevailing in these soils can be of $Cl^-$ and $HCO_3^-$ type. The results are in line with those reported by Polara et al*.* [21], Kabaria and Polara [22] for soils of Amreli district, Polara et al*.* [23] for North-West Agroclimatic Zone of Gujarat and Marsonia et al*.* [24] for Porbandar district [25].

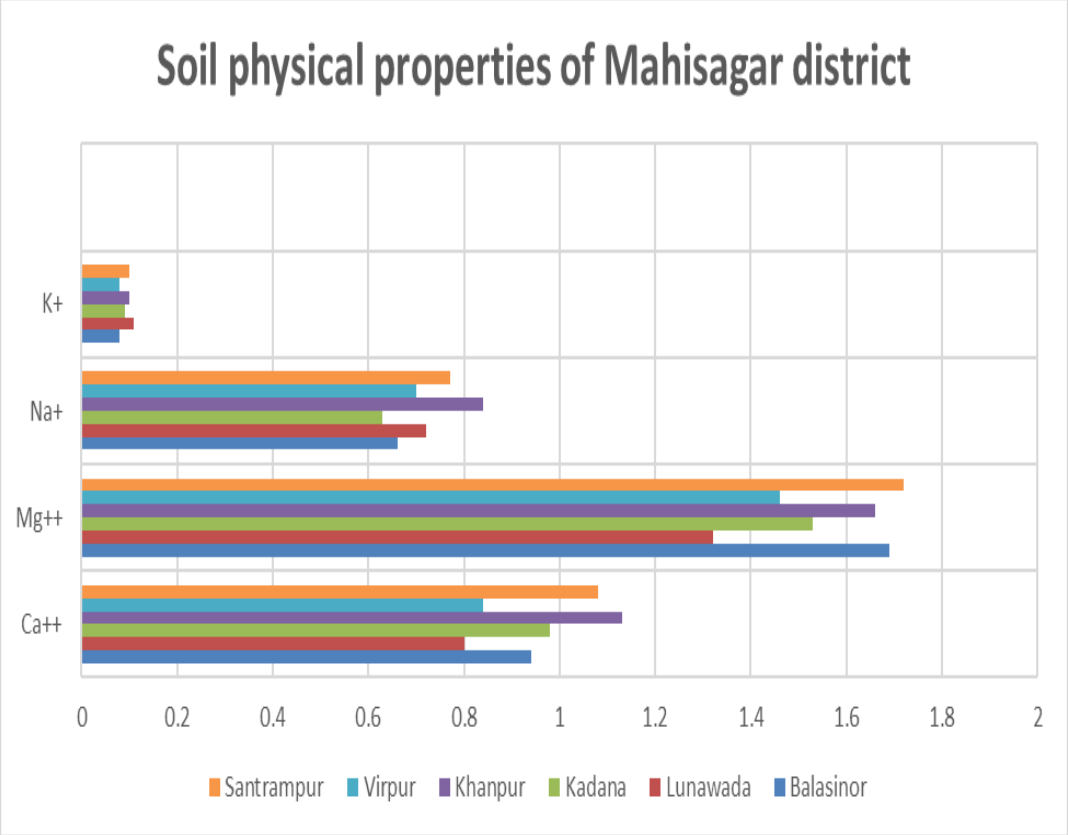


**Fig. 1. Taluka wise mean values for Soil physical properties of Mahisagar district**

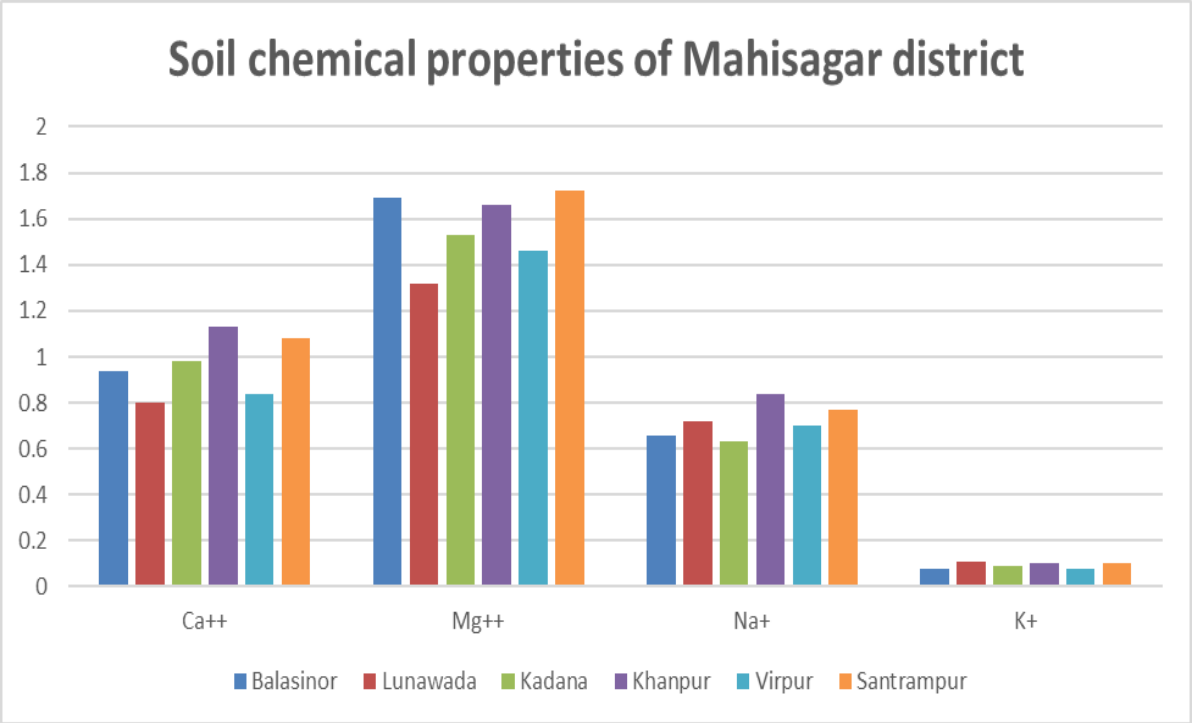


**Fig. 2. Taluka wise mean values for Soil chemical properties of Mahisagar district**

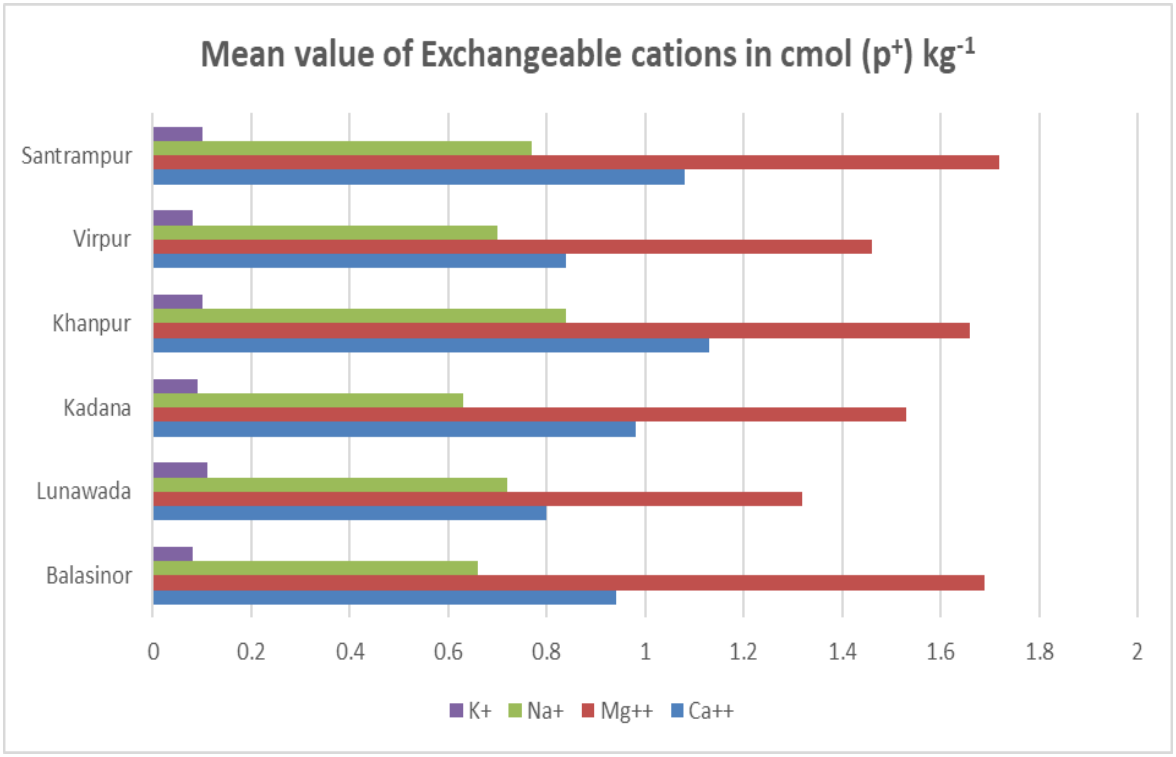


**Fig. 3. Taluka wise mean values for Soil Exchangeable cations ($p^+$) $kg^{-1}$ in soil of Mahisagar district**

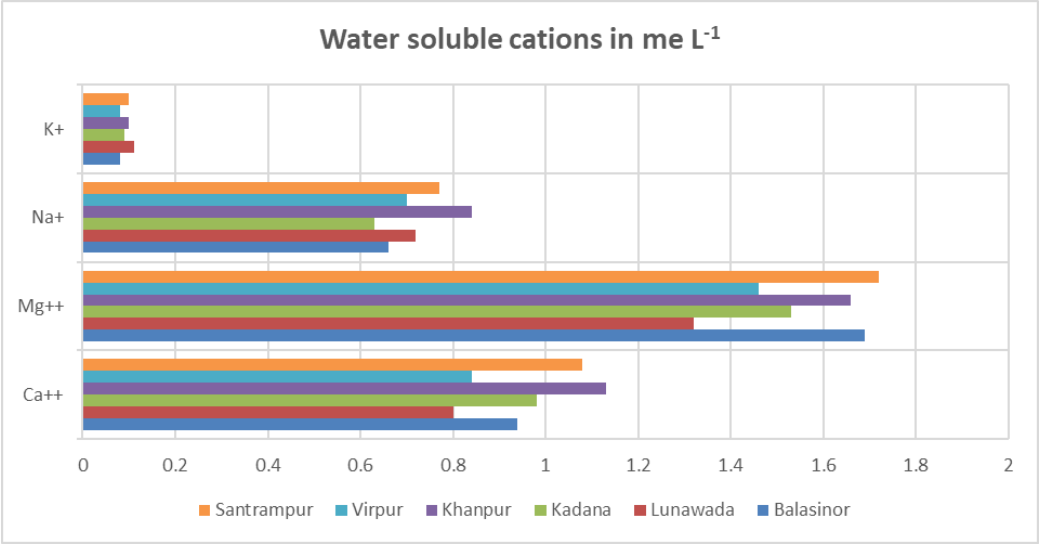


**Fig. 4. Taluka wise mean values for water soluble cations (me $L^{-1}$) in soil of Mahisagar district**

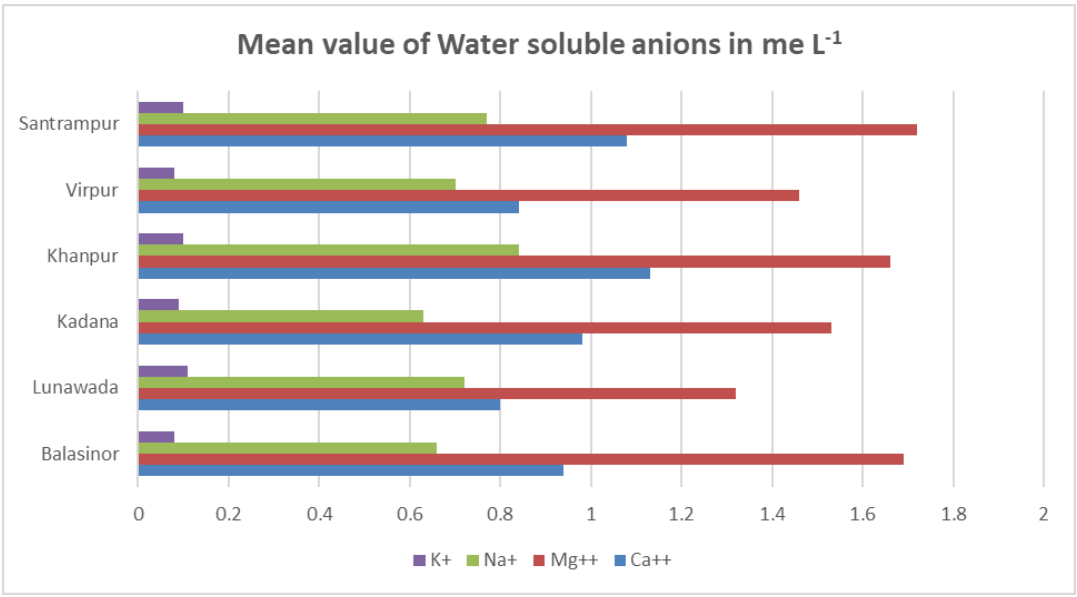


**Fig. 5. Taluka wise mean values for water soluble anions (me $L^{-1}$) in soil of Mahisagar district**

**Table 5. Taluka wise range and mean values of water-soluble anions in soils of Mahisagar District**

| Name of taluka | Water soluble anions in me $L^{-1}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $CO_3^{--}$ | | $HCO_3^-$ | | $Cl^-$ | | $SO_4^{--}$ | |
| | Range value | Mean value | Range value | Mean value | Range value | Mean value | Range value | Mean value |
| Balasinor | 0.0-0.0 | 0.0 | 2.00-9.00 | 3.3 | 2.40-10.0 | 4.24 | 0.15-1.42 | 0.35 |
| Lunawada | 0.0-0.0 | 0.0 | 1.0-4.00 | 2.8 | 2.40-12.80 | 4.28 | 0.06-1.78 | 0.41 |
| Kadana | 0.0-0.0 | 0.0 | 2.00-5.00 | 3.3 | 2.40-8.0 | 4.11 | 0.09-0.77 | 0.26 |
| Khanpur | 0.0-0.0 | 0.0 | 2.0-5.00 | 3.4 | 2.80-17.40 | 5.39 | 0.08-1.83 | 0.49 |
| Virpur | 0.0-0.0 | 0.0 | 2.00-5.00 | 3.0 | 2.40-8.40 | 4.11 | 0.06-1.45 | 0.29 |
| Santrampur | 0.0-0.0 | 0.0 | 2.00-6.00 | 3.3 | 2.80-17.60 | 4.33 | 0.06-1.50 | 0.28 |

## 4. CONCLUSIONS

soil testing is an important aspect of agriculture as it helps in analyzing the soil for its fertility evaluation, and results are useful for recommending the type and amount of fertilizers and other amendments for increased and profitable crop production. In general, to increase productivity, it is important to optimize the utilization of natural resources such as water and climate without impairing the environment. The soils of Mahisagar districts have low bulk density (1.32 Mg $m^{-3}$) and particle density (2.53 Mg $m^{-3}$). This indicates good physical condition of soil. The soils of Mahisagar districts are alkaline in reaction with high in organic carbon. Being the light to medium texture soils, its overall cation exchange capacity is 24.47 cmol ($p^{+}$) $kg^{-1}$. Magnesium is the dominant-exchangeable cation, whereas magnesium and chloride are dominant water-soluble ions. About 3.0, 1.0, 20 and 76 per cent soil samples are found saline, saline-sodic, sodic and normal, respectively.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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