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Assessment of molybdenum status in soils of Washim district of Maharashtra

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Abstract

Georeferenced surface soil samples from six tehsils in Washim district of Maharashtra were collected during 2024-25 using grid sampling technique with grid of 5 km total 120 georeferenced surface soil samples (0-20) collected randomly with GPS assistance. The soil samples using GPS representing each square by dividing toposheet of district and from each square the representative soil sample was collected so that the sampling sites were well distributed in the district. The fertility maps were prepared using Geographical Information System for each nutrient. The results revealed that the soils of Washim district were found to be neutral to strongly alkaline reaction with pH range of 6.9 to 8.82. The EC was varied from 0.09 to 0.88 dS m⁻¹, which indicates that soils were non saline and suitable for healthy crop growth. The low to high organic carbon was found in soils of Washim, with range of 0.32 to 1.53%. The calcium carbonate content found in Akola district were found to be 1.13 to 21.75 percent, which replicates that soils of Washim district were non calcareous in nature. The available nitrogen content in Washim district found in range of 81.5 to 175.6 kg ha⁻¹ with nutrient index 0.75, the nitrogen deficiency was recorded to the extent of 48.33% in soils of Washim district of Maharashtra. The available molybdenum content in Washim district varied from 0.03 to 0.680 mg kg⁻¹, with of nutrient index of 1.72 which falls under moderate category. However, positive and significant correlation between pH and available molybdenum and calcium carbonate and available molybdenum were respectively ($r = +0.818^{**}$) and ($r = +0.398^{**}$). Whereas significant and negative correlation with EC (-0.231^{*}). Also non-significant and negative correlation between available molybdenum with both organic carbon ($r = -0.052^{NS}$) and available nitrogen ($r = -0.114^{NS}$).

Keywords: Washim district, soil fertility, georeferenced soil sampling, available molybdenum

1. Introduction

Molybdenum (Mo) is an essential micronutrient found naturally in soils and is needed in very small amounts for the normal growth and development of plants and animals. It play a crucial role in nutrient metabolism and regulate a range of biochemical processes that are necessary for proper plant growth, development and overall metabolic activity. When the supply of molybdenum is insufficient, leaves gradually become pale green or yellow because of reduced chlorophyll formation and overall plant growth is adversely affected. Prolonged deficiency can also disrupt flowering and reproductive development, resulting in early senescence and wilting of plants. Plants primarily absorb molybdenum in the form of the molybdate ion (MoO₄²⁻), which is the dominant soluble and plant-available form under neutral to alkaline soil conditions. The solubility and availability of molybdate generally increase as soil pH rises, making alkaline soils more favourable for Mo uptake. In contrast, under acidic conditions (pH < 5.5), molybdate ions are strongly adsorbed onto iron and aluminium oxides present in the soil, thereby reducing their availability to plants (Grath *et al.* 2010) [6]. In dicotyledonous species, a distinctive symptom of molybdenum deficiency is the formation of narrow, malformed, or poorly developed leaf blades. These deformities are mainly caused by abnormal vascular tissue differentiation during the early stages of leaf development and are often associated with localized necrotic lesions (Mengel *et al.* 2012) [11].

2. Materials and Methods

2.1 Location: Washim district is situated between approximately 19° 47' and 20° 51' North latitude and 76° 57' and 77° 55' East longitude. It is located in the Vidarbha region of Maharashtra and is divided into six tehsils (Washim, Malegaon, Risod, Mangrulpir, Karanja and Manora). To the north of Washim district lies Akola district, while Yavatmal district is situated towards the east. Buldhana district forms its western boundary and Hingoli district lies to the south. Amravati district also borders Washim on the north-eastern side. The soils of Washim district have primarily developed from the weathering of Deccan Trap basaltic rocks, which constitute the dominant geological formation of the region. The district is characterized by the occurrence of deep black, medium black, shallow black and alluvial soils. Among these, deep and medium black cotton soils (Vertisols) are the most extensive and agriculturally important soil types, occupying a major portion of the district. Washim district experiences a tropical monsoon climate, characterized by hot summers, a distinct southwest monsoon season and mild winters. The maximum temperature generally ranges between 40°C and 44°C, while the minimum temperature varies from 25°C to 30°C. The winter season extends from November to February and is pleasant, with temperatures generally ranging between 10°C and 15°C, although minimum temperatures may occasionally fall below 10°C during cold wave conditions.

2.2 Sampling and analysis: Surface (0-20 cm) soil samples representing different soils were collected. The sampling sites were selected randomly in the district, so the sampling sites scattered uniformly in each tehsils of Washim district. The soil samples were collected at 5km distance with grid sampling from all the tehsils of Washim district of Maharashtra. One hundred and twenty soil samples were collected from the district. Soil pH was determined with the help of pH meter in 1: 2.5 soil water suspensions as described by (Jackson 1973) [9]. EC of the soil samples were determined in clear supernatant liquid obtained from 1:2.5 soil water suspension with the help of conductivity meter (Jackson 1973) [9]. Organic carbon of the samples was determined by Walkely and Black wet-oxidation method (1934) [19]. Calcium carbonate was determined by rapid titration method as given by Piper (1966) [14]. Available nitrogen was determined by alkaline permanganate method as given by Subbiah and Asija (1956) [18]. Available molybdenum was determined by Grigg's reagent method given by Grigg (1953) [7]. Ammonium oxalate method is the most popular for extraction of available molybdenum from soil colour intensity was read at 680 nm using spectrophotometer. The data pertaining to available nitrogen and molybdenum were categorized in six tier system (Table 2) i.e. acute deficient, deficient, latent deficient, marginal sufficient, adequate and high is taken from (Shukla and Behera, 2019) [16] and (Dahliwal *et al.* 2020) [4]. The nutrient indices were calculated by using formula given by (Ramamoorthy and Bajaj, 1969) [15] and Stalin *et al.* (2010) [17]. Correlation of available molybdenum with pH, EC, organic carbon, calcium carbonate and available nitrogen were determined as described by Panse and Sukhatme (1985) [13].

$$\text{Nutrient index} = \frac{[\text{NAD} \times 0.5 + \text{ND} \times 1 + \text{NLD} \times 1.5 + \text{NMS} \times 2 + \text{NA} \times 2.5 + \text{NH} \times 3]}{\text{Total number of samples}}$$

3. Results and Discussion

3.1 Physio Chemical properties and available molybdenum status of soil: The data regarding to Physico-chemical

properties was recorded in Table 3. The range soil pH in Washim district is from 6.79 to 8.82 indicating that neutral to strongly alkaline reaction. The mean of soil pH of Washim district is (8.05). The pH of organic farm soils ranged from 7.0 to 7.9. The mean of pH was 7.44. Soils are in general neutral to moderately alkaline in nature, it might be due to medium deep black soils brought under irrigation since long that have shifted to alkaline condition Chavan *et al.* (2016) [3]. The soils of Washim showed electrical conductivity (EC) values ranged from 0.09 to 0.88 dS m⁻¹. The electrical conductivity (EC) gives an indication about salt concentration of the soil and it varied from 0.02 to 0.59 dS m⁻¹ and an average value of 0.14 dS m⁻¹. All the soils were non saline in nature and suitable for healthy plant growth Hadole *et al.* (2020) [8]. The organic carbon content of Washim district varied from 0.32% to 1.53% with the mean value 0.76%. Dhotare *et al.* (2019) [5] reported that the soils were low to moderately high in organic carbon content (0.23 to 0.89%). The low content of organic carbon might be due to slow rate of decomposition and continuous utilization by plants for the uptake of nutrients. The calcium carbonate content of Washim district soils ranged from 1.13 to 21.75 percent with mean of 7.37 percent which indicates that soils are non-calcareous to calcareous in nature. The calcium carbonate content of the surface soils of dryland research farm, Dr. PDKV Akola, Maharashtra ranged from 2.8 to 6.9%. It indicates that these soils are moderately calcareous to calcareous in nature. The precipitation of calcium carbonate from the solution rich in carbonate resulted in the high pH values. Arati Rathod *et al.* (2019) [1].

All available nitrogen and molybdenum samples can be categorized into acute deficient, deficient, latent deficient, marginal sufficient, adequate, high, categories. (Shukla and Behera, 2019) [16] and (Dahliwal *et al.* 2020) [4]. Table 5 shows that Washim district had the available nitrogen in Washim district ranged from 81.5 to 175.6 kg ha⁻¹. The Highest and lowest mean of available nitrogen content was observed in Manora (141.7) and Risod (118.4) kg ha⁻¹. The mean of available nitrogen of Washim district is 130.3 kg ha⁻¹. Washim tehsil recorded 90% acute deficient samples. The nutrient index was found in Washim district 0.75 which falls under very low category. Highest and lowest nutrient index values in Manora and Washim tehsils were recorded 0.90 and 0.55 respectively.

The available molybdenum of seven tehsils of Washim district of Maharashtra ranges from 0.03 to 0.680 mg kg⁻¹, which indicate that soils are deficient to adequate in molybdenum availability with mean 0.290 mg kg⁻¹. The highest and lowest mean of available molybdenum was recorded in Karanja (0.380 mg kg⁻¹) and Malegaon (0.190 mg kg⁻¹) in tehsils of Washim district. Available molybdenum ranges from 0.030 to 0.680 mg kg⁻¹ which indicate that soils are deficient to adequate in molybdenum availability with mean 0.290 mg kg⁻¹. The soils of Washim district vary from acute deficient to high content. In all tehsils of washim district were found acute deficient (23.33%) in category of available molybdenum followed by deficient (10.83%), latent (14.16%), marginal sufficient (16.56%), adequate (20%) and high (15%). The nutrient index value (Table 5) in all over the tehsils of Washim was found moderate range (1.72). Arati Ghatole *et al.* (2020) [2] recorded available molybdenum varied from 0.01 to 0.62 mg kg⁻¹ in Sindhudurg district with mean of 0.25 mg kg⁻¹. The nutrient index was recorded (1.82). However the 38.35 per cent soil samples were found deficient in available molybdenum.

Table 1: Categories of Nutrient Index Values (NIV)

NIV Index	Very low	Low	Moderate	Moderately high	High	Very High
	<1.33	1.33-1.66	1.66-2.00	2.00-2.33	2.33-2.66	>2.66

Table 2: Categories of available nitrogen and molybdenum

Catagories	Acute Deficient	Deficient	Latent Deficient	Marginal Sufficient	Adequate	High
Nutrients						
N (kg ha ⁻¹)	< 130	130-250	250-370	370-510	510-650	>650
Mo (mg Kg ⁻¹)	< 0.09	0.09-0.17	0.17-0.26	0.26-0.38	0.38-0.52	>0.52

Categories for available nitrogen and available molybdenum in six tier system i.e acute deficient, deficient, latent deficient,

marginal sufficient, adequate and high is taken from (Shukla and Behera, 2019) ^[16] and (Dahliwal *et al.*2020) ^[4].

Table 3: Tehsil wise status of Physico-chemical properties in soils of Washim district

Tehsils	pH (1:2.5)		EC (dS m ⁻¹)		OC (%)		CaCO ₃ (%)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Mangrulpir	7.03-8.38	8.00	0.14-0.88	0.22	0.40-1.11	0.63	2.25-15.63	9.60
Manora	7.63-8.39	8.09	0.11-0.42	0.18	0.32-0.82	0.59	2.88-21.75	8.26
Karanja	7.17-8.66	8.30	0.13-0.23	0.16	0.55-1.40	0.79	2.75-17.13	6.61
Malegaon	6.79-8.56	7.78	0.14-0.75	0.26	0.57-1.53	0.90	1.13-13.26	5.80
Risod	7.10-8.35	7.95	0.09-0.30	0.18	0.31-1.33	0.88	2.75-12.63	6.89
Washim	7.78-8.82	8.16	0.10-0.37	0.16	0.50-1.17	0.76	3.75-11.25	6.48
Overall average	6.79-8.82	8.05	0.09-0.88	0.19	0.32-1.53	0.76	1.13-21.75	7.37

Table 4: Tehsil wise status of available nitrogen in soils of Washim district

Name of Tehsil	Range	Mean	Number of samples						
			Acute.	Def.	Lat.	Mar. Suf.	Ade.	High	NIV
Mangrulpir	112.9-175.6	137.9	8 (40.00)	12 (60.00)	0	0	0	0	0.80
Manora	94.0-175.6	141.7	4 (20.00)	16 (80.00)	0	0	0	0	0.90
Karanja	94.0-169.5	133.1	11 (55.00)	9 (45.00)	0	0	0	0	0.77
Malegaon	112.9-163.0	138.1	6 (30.00)	14 (70.00)	0	0	0	0	0.85
Risod	87.8-144.2	118.4	11 (55.00)	9 (45.00)	0	0	0	0	0.77
Washim	81.5-137.9	114.7	18 (90.00)	2 (10.00)	0	0	0	0	0.55
Total	81.5-175.6	130.7	58 (48.33)	62 (51.66)	0	0	0	0	0.75

(Figures in parenthesis are percentage)

Table 5: Tehsil wise status of available molybdenum in soils of Washim district

Name of Tehsil	Range	Mean	Number of samples						
			Acute.	Def.	Lat.	Mar. Suf.	Ade.	High	NIV
Mangrulpir	0.05-0.540	0.260	5 (25.00)	3 (15.00)	3 (15.00)	4 (20.00)	3 (15.00)	2 (10.00)	1.57
Manora	0.06-0.590	0.300	5 (25.00)	1 (5.00)	3 (15.00)	4 (20.00)	3 (15.00)	4 (20.00)	1.77
Karanja	0.07-0.630	0.380	2 (10.00)	1 (5.00)	3 (15.00)	3 (15.00)	6 (30.00)	5 (25.00)	2.02
Malegaon	0.03-0.520	0.190	8 (40.00)	4 (20.00)	2 (10.00)	3 (15.00)	2 (10.00)	1 (5.00)	1.25
Risod	0.05-0.520	0.240	6 (30.00)	3 (15.00)	3 (15.00)	3 (15.00)	4 (20.00)	1 (5.00)	1.47
Washim	0.06-0.680	0.360	2 (10.00)	1 (5.00)	3 (15.00)	3 (15.00)	6 (30.00)	5 (25.00)	2.12
Total	0.03-0.680	0.290	28 (23.33)	13 (10.84)	17 (14.16)	20 (16.67)	24 (20.00)	18 (15.00)	1.72

(Figures in parenthesis are percentage)

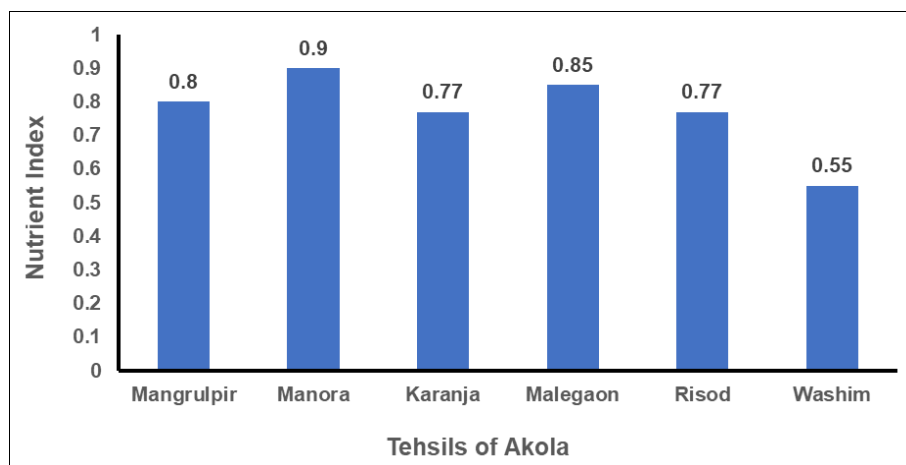
Table 6: Karl Pearson's correlation of available molybdenum with soil properties

Sr. No.	Parameters	Available Mo
1.	pH	0.818**
2.	EC	-0.231*
3.	OC	-0.052 ^{NS}
4.	CaCO ₃	0.398**
5.	N	-0.114 ^{NS}
6.	Mo	1.000

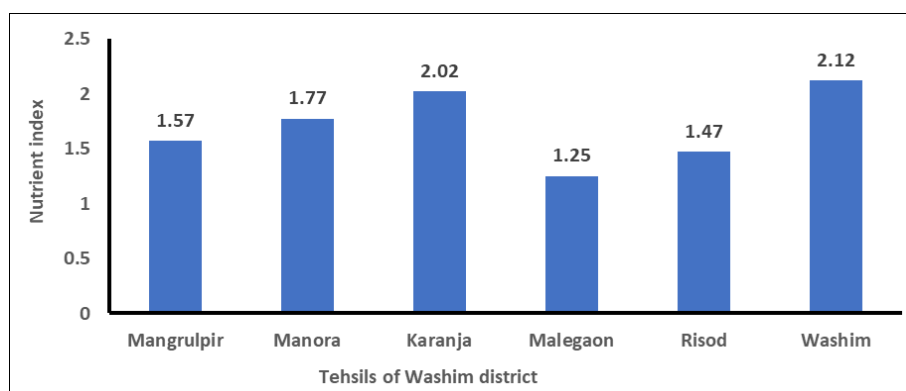
* Significant at 5% level ** Significant at 1% level

Relationship of available molybdenum with soil properties: positive correlation between pH and available molybdenum ($r=+0.818^{**}$). Medhe *et al.* (2012) ^[10] also reported that availability Mo in soils of Chakur tahsil had significant and positive

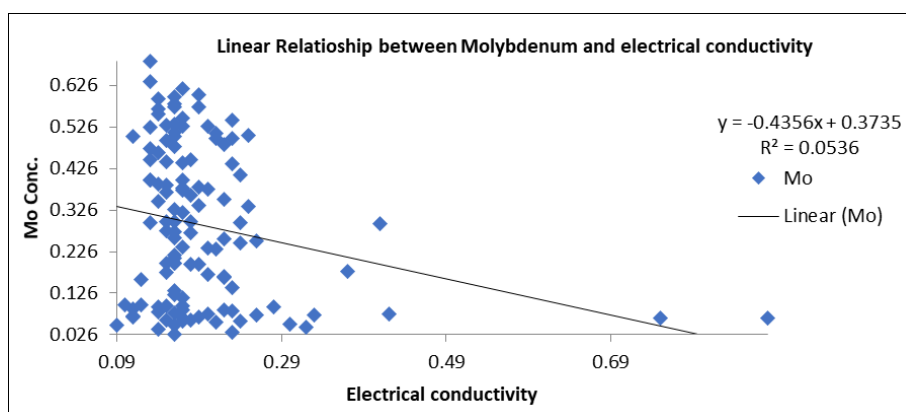
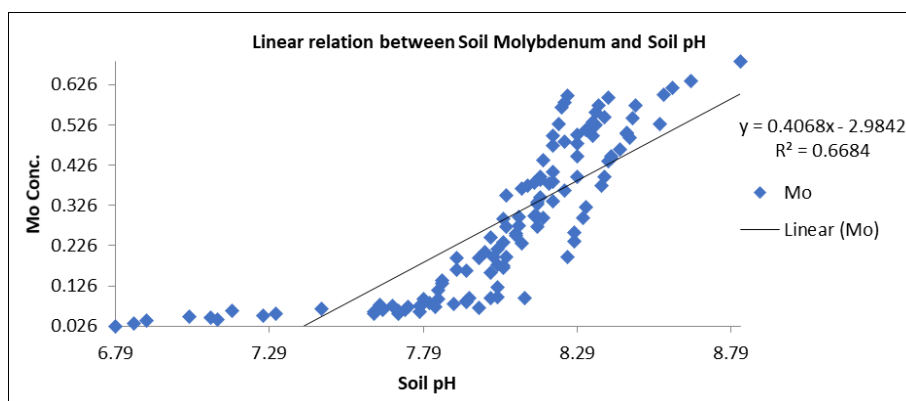
correlation with soil pH ($+0.665^{**}$) available molybdenum had highly significantly positive correlated with pH. Available soil molybdenum increases with increase in soil pH. The available molybdenum found to have a significant and negative correlation with EC ($r= -0.231^{**}$). Nilam Kondvilkar *et al.* (2015) ^[12] found that molybdenum had non-significant and negative with EC (-0.039^{NS}). There was also significant and positive correlation between calcium carbonate and available molybdenum ($r= +0.398^{**}$). Available molybdenum showed non-significant and negative correlation between available molybdenum and organic carbon ($r= -0.052^{NS}$). Nilam Kondvilkar *et al.* (2015) ^[12] found that non-significant and negative with OC (-0.021^{NS}). There was a non-significant and negative correlation between available molybdenum and available nitrogen ($r= -0.114^{NS}$).

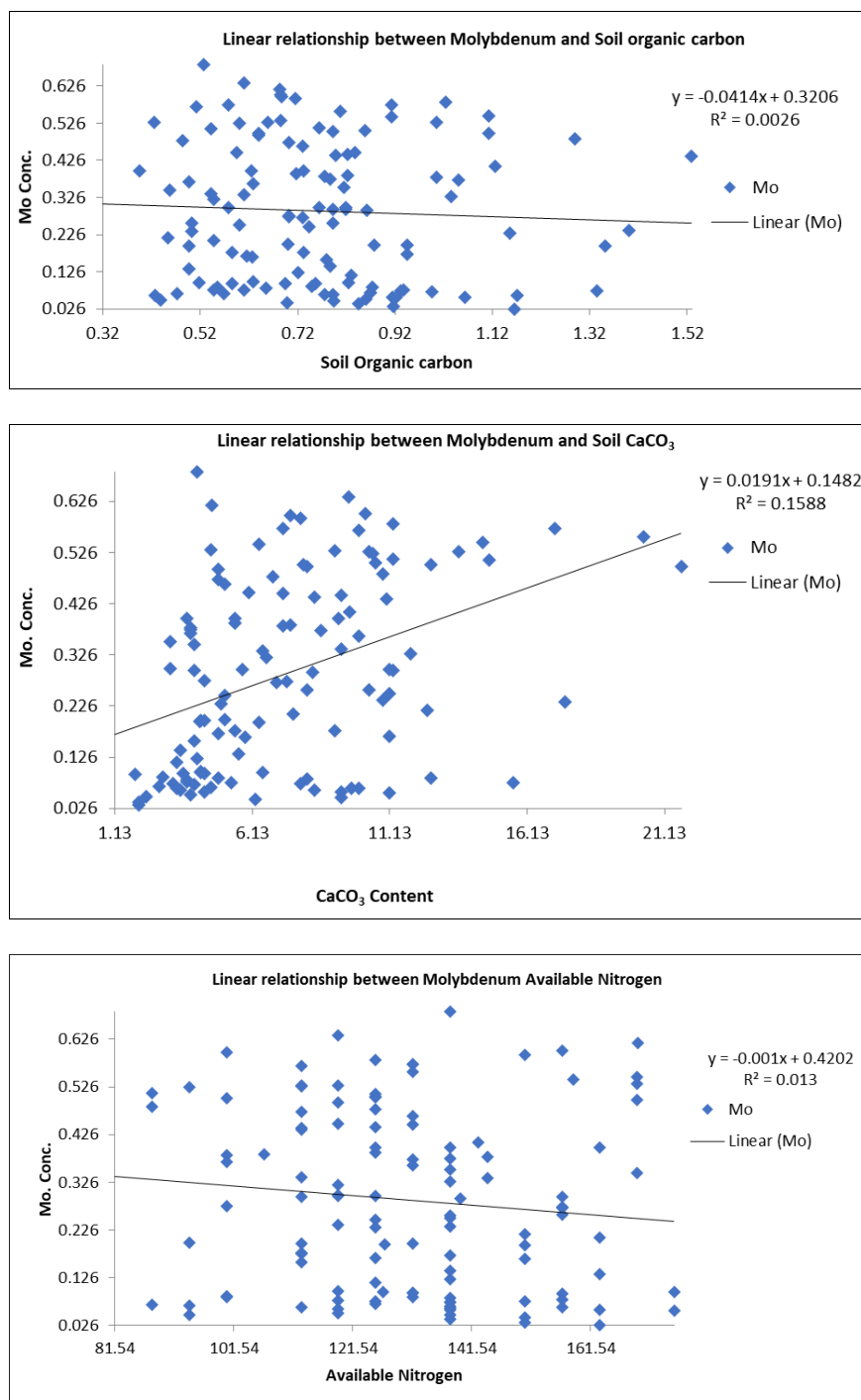


Graph 1: Status of nutrient index of available nitrogen in various tehsils of Washim district

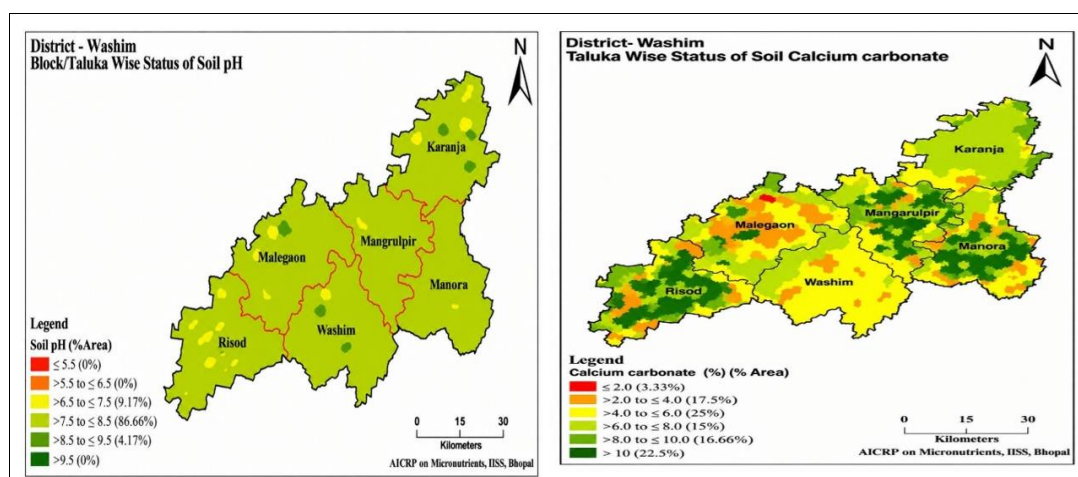


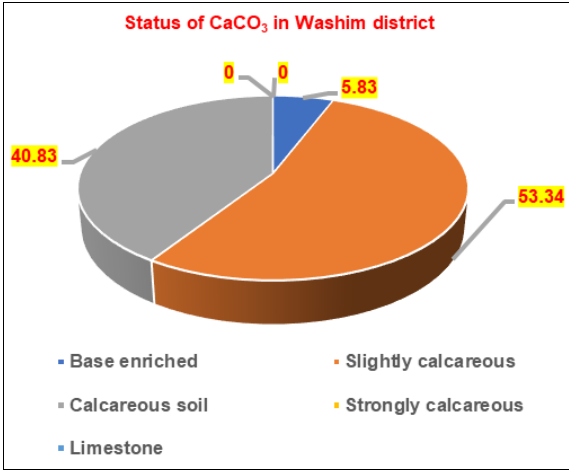
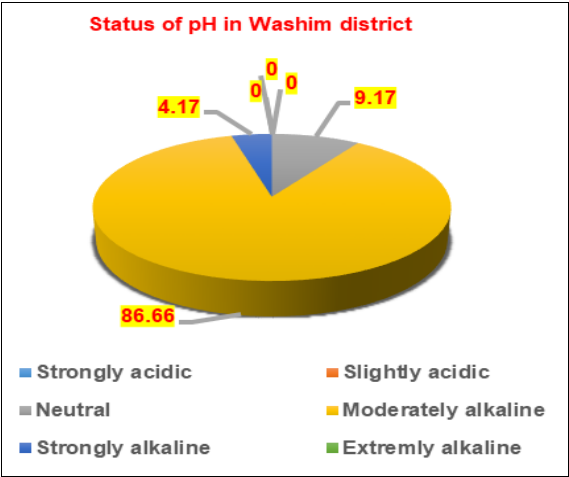
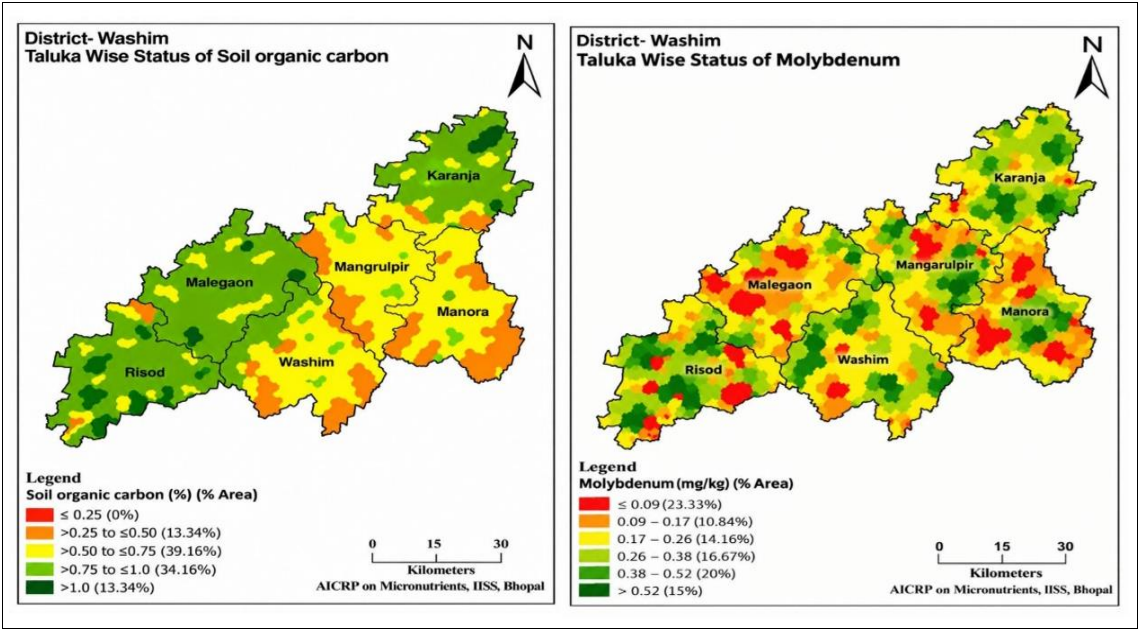
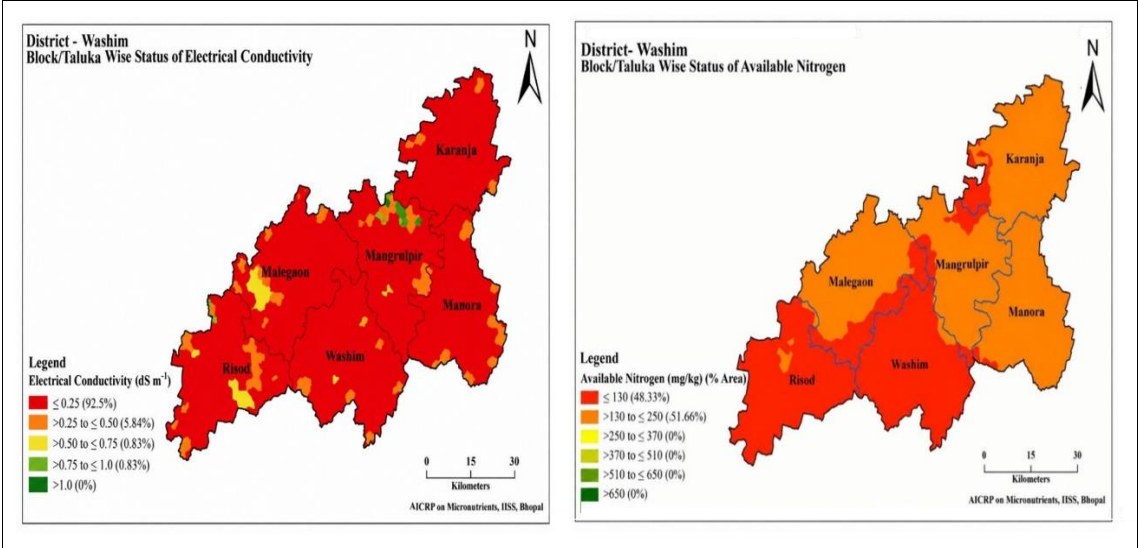
Graph 2: Status of nutrient index of available molybdenum in various tehsils of Washim district

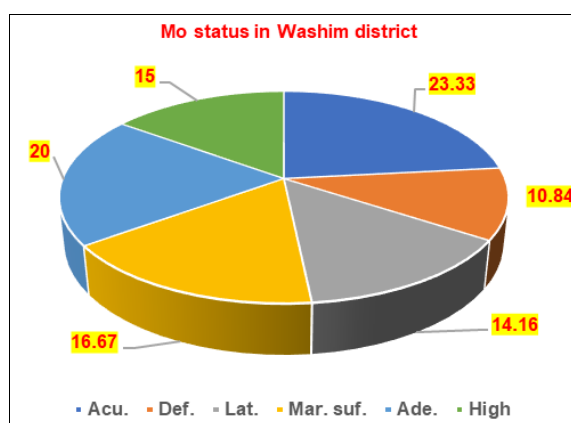
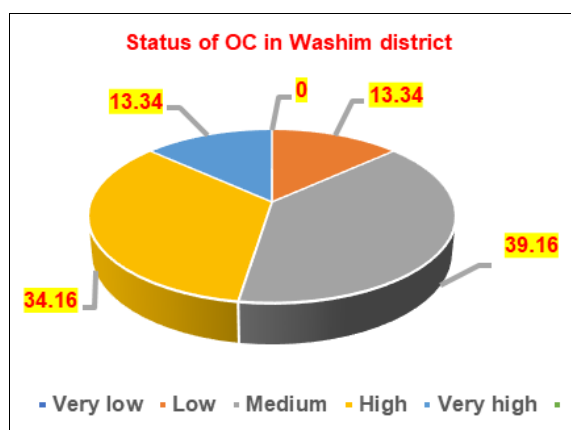
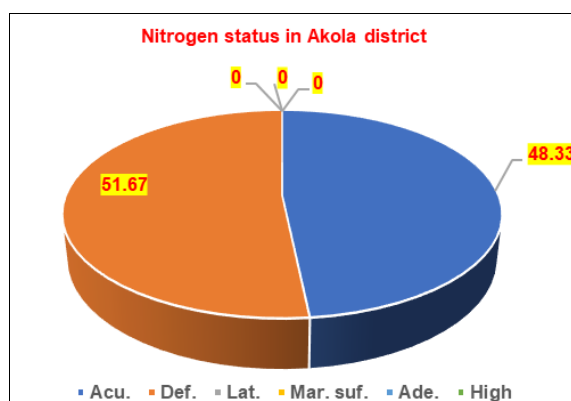
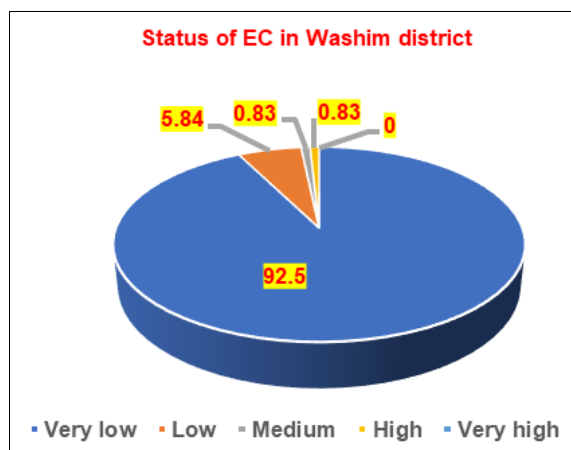




Graph 3: Linear relationship of available molybdenum (mg kg^{-1}) with other soil properties.







Status of physio chemical properties and available nutrients in Washim

4. Conclusion: From the present investigation, in Washim district the content of soil pH, EC, organic carbon, calcium

carbonate, available nitrogen and available molybdenum ranged from 6.79-8.82, 0.09-0.88dS m⁻¹, 0.32-1.53%, 1.13-21.75%, 81.5-175.6 kg ha⁻¹ and 0.030-0.680 mg kg⁻¹ respectively. The deficiency of available nitrogen, and molybdenum to the extent of 48.33% and 23.33% respectively. The nutrient index value found low for nitrogen and molybdenum.

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