Soil Fertility Evaluation of Soils of Gwalior District (M.P.)

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SOIL SCIENCE & AGRICULTURAL CHEMISTRY

by

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2016

CERTIFICATE – I

This is to certify that the thesis entitled **Soil Fertility Evaluation of Soils of Gwalior District (M.P.)** *submitted in partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE** *in* **Soil Science & Agricultural Chemistry** *of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafide research work carried out by Mr.* **RAHUL SHARMA** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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This is to certify that the thesis entitled **Soil Fertility Evaluation of Soils of Gwalior District (M.P)** *Submitted by Mr.* **RAHUL SHARMA** *to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfillment of the requirements for the degree of Master of Science in* **AGRICULTURE** *in the Department of* **Soil Science & Agricultural Chemistry** *has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an oral examination of the same.*

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Abbreviations and Acronyms

Abbreviations/ Acronyms	Meaning
Ag.	Agriculture
B	Boron
Cu	Copper
et al.	And co-workers
cm	Centi metre
dSm^{-1}	Deci Siemens per meter
^{o}C	Degree centigrade
Dist.	District
EC	Electrical conductivity
F	Fertility
Fe	Iron
Fig.	Figure
FYM	Farm yard manure
g	Gram
ha	Hectare
i.e.	In reference to; that is
Kg	Kilogram
kg ha^{-1}	Kilogram per hectare
Max.	Maximum
m	Metre
mg kg^{-1}	Milli gram per kilogram
Min	Minimum
M.P.	Madhya Pradesh
Mn	Manganese
Viz	Namely
N	Nitrogen
No.	Number
OC	Organic carbon
O.M.	Organic manure
%	Per cent
K	Potassium
P	Phosphorus
RDF	Recommended dose of fertilizer
RH	Relative humidity
R.V.S.K.V.V.	Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya
pH	Soil reaction
Q	Quintal
S	Sulphur
Sy.	Symbol
Temp.	Temperature
t ha^{-1}	Tonnes per hectare
U.P.	Uttar Pradesh
Wt.	Weight
PUE	Phosphorus use efficiency

BD	Bulk density
PD	Particle Density
WHC	Water holding capacity
FYM	Farm yard manure
DM	Dry matter
&	And
@	At the rate of

Chapter - I

INTRODUCTION

Soil fertility is one of the important factor controlling yields of the crops. Macronutrients (N, P, and K) and micronutrients (Zn, Cu, Fe, B and Mn) are important soil elements that control its fertility. Soil characterization in relation to evaluation of fertility status of the soil of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalanced and inadequate fertilizers use and coupled with low efficiency of others inputs, the response (production) efficiency of chemical fertilizers nutrients declined tremendously under intensive cultivation in recent years. Variation in nutrients supply is a natural phenomenon and some of them may be sufficient where other deficient.

Plants require nutrients in adequate and right proportion for optimum growth, is one of the key component to determine soil productivity. Management of the fertility of Indian soils demands its build up and Soil fertility refers to the inherent capacity of a soil to supply essential nutrients to sustain at a high level to produce adequate food to feed its burgeoning population. Proper management of soil fertility demands careful identification of constraints of current nutrient deficiencies and monitoring changes in soil fertility to predict its deficiency. These deficiencies need to be alleviated through sound and proven practices of nutrients, water, crops and energy to soil management, so as to sustain food production at a reasonable level to ensure continued high productivity in the future. Thus management of soil fertility vis-à-vis nutrient management at optimum level is one of the key factors in achieving high and sustainable productivity.

Land degradation, either natural or induced by humans, is a continuing process. It has become, however, an important issue through its adverse effects on national natural resources. Causes for land degradation are numerous and include decline of soil fertility, development of acidity, salinization, alkalization, deterioration of soil structure accelerated wind and water erosion, loss of organic matter and biodiversity. At present sulphur deficiency increased in north-western states, the region is continuously and unscientifically growing oil seeds crops. The agriculture will not be sustainable unless soil health is managed scientifically to meet present and future needs. Low fertility of Indian soil is the major constraint to achieve high productivity goals. Widespread deficiencies of N,P,K,S Zn, Fe etc have emerged and significant crop response to application of these nutrients have been reported .Soil fertility decline is naturally more alarming in intensive cultivate regions. Soils in north-western states in India available nitrogen were found 56.48% in low, 27.25% medium and only 16.27% in high contents. In Uttar Pradesh, Punjab, Rajasthan and Haryana, most of the soils (55.55% to 61.66%) were low, some (19.63 to 32.80%) were medium and few (10.78% to 18.71%) were high in nitrogen contents . Soil of Gujarat, Uttarakhand, and Jammu & Kashmir were low to medium whereas in Chhattisgarh, Himachal Pradesh and Madhya Pradesh were medium to high contents in available nitrogen contents. Most of the soils (61.02%) were low, some (25.89%) were medium and few (13.09%) were high in available phosphorus contents. Madhya Pradesh is the state, where maximum soils (85.45%) were found high and least soil (1.01%) were low in available potash contents. In Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Uttarakhand and Jammu & Kashmir most of the soils (42.14 to 68.79%) were found in medium whereas other states like Rajasthan, Gujarat and Chhattisgarh soils were found in medium to high content in available potash content. All soils of North- Western states in India were low in available phosphorus state except Punjab where it was medium and west Bengal & Assam were high .ON overall basis, it may be concluded that soil of North-Western India were low in available nitrogen & phosphorus and high in available potash status. Soils of North-Western states in India, available Zn contents were found 65.37 % deficient. The maximum soil were found Zn deficient in Jammu & Kashmir (88.94 %) followed by Rajasthan (84.68%) Punjab (52.87%), Uttar Pradesh (45.56%) and Haryana (41.18%).

Iron has found deficient in north-western states in India was 58.17% and Copper 21.09% Rajasthan was maximum deficient in copper (28.19%) then U.P. (17.91%). Mangnese deficient in soils was observed in the range 9.79% to 43.53% being minimum in Madhya Pradesh (9.79%) and maximum in Jammu & Kashmir.

Nitrogen being as essential constituent of protein is a vitally important plant nutrient the soil of northern Madhya Pradesh are inherently poor in nitrogen and crops grown on them show deficiency symptoms in almost all the field where it is not applied .an adequate supply of nitrogen is generally associated with vigorous vegetative growth of plants and dark green color of leaves .

Phosphorus stands next in importance among the essential nutrients and the soil of the region are low in p content. Phosphorus, amongst NPK can be called "the master key" with respect to the yield and quality of crops. It is useful for the absorption of different nutrients as the most prominent effect of P has been observed on the root system of the plants as it promotes the formation lateral and fibrous roots.

Potassium is essential for various metabolic activities of living cell, transformation of carbohydrates, reduction of nitrates, synthesis of protein and normal meristematic activities where it acts as a catalyst or as a co-factor in enzymatic reaction of living cell. It has been suggested that potassium may also affect photosynthesis maintenance of turgid in plant cells as well as formation of oil and imparting diseased resistance.

There are reports of reduction in yield even due to constant use of NPK fertilizers. The reduction in the yield generally traced due to deficiency of secondary nutrients and micronutrients.

Indian soils are generally poor in fertility, as these have consistently been depleted of their finite nutrient resources due to continuous cultivation from many centuries. Soil-test summaries indicate that 98 per cent Indian soils have low medium in available P and 60 per cent soil have low to medium in K status ,whereas N continue to be universally deficient. About 47 soils are deficient in Zn, 12 per cent in Cu and 4 per cent in Mn. In same states and crops, the deficiency of B and Mo are also limiting the crop production. In last one and half decades a phenomenal increase is S deficiency has been witnessed under intensive cropping system where high-analysis fertilizers devoid of S are used and some regions where cultivation of rice are continues witnessed deficiency of zinc.

Gwalior district is situated in the northern part of Madhya Pradesh. The farmers of the area are generally growing mustard, pea, gram and wheat in *Rabi* and til, pearl millet, black gram, sorghum and green gram in *Kharif* season. The common cropping systems are followed by farmers are cereal – cereal, cereal-legumes and cereal-oil seeds.

Role of micronutrients in balanced plant nutrition is well established. However, exploitive nature of modern agriculture involving use of high analysis NPK fertilizers coupled with limited use of organic manures and less recycling of crop residues are important factors contributing accelerated exhaustion of micronutrients from soil. The macro and micronutrient govern the fertility of the soils and control the yields of the crops. Soil characterization in relation to evaluation of micronutrient status of the soils of an area is an important aspect in context of sustainable agriculture production. The stagnation in crop productivity cannot be boosted without judicious use of micronutrient fertilizers to overcome deficiencies/imbalances.

Micronutrient plays a vital role in maintaining soil health and also productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth of plants and synthesis of human food. Increased removal of micronutrients as a consequence of adaption of HYVs and intensive cropping together with shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained. The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soils. Soils with finer particles and with higher organic matter can generally provide a greater reserve of these elements whereas, coarse textured soils such as, sand have fewer reserves and tend to get depleted rather quickly. The availability of micronutrients to plants is influenced by soil characteristics. For an effective correction of a micronutrient deficiency in the field, it is necessary to understand the reasons of its deficiency in the soil. Work on micronutrient in soils of Gwalior district of Madhya Pradesh has not been done much more so far. The availability of micronutrients to plants is influenced by other soil characteristics (Singh *et al*. 1989). For an effective correction of a micronutrient deficiency in the field, it is necessary to understand the reasons of its deficiency in the soil. Although widespread micronutrients deficiency of micronutrients especially zinc has been observed in the soils of M.P. The information with respect to availability of micronutrients and soil characteristics of the Gwalior district of Madhya Pradesh was lacking.

The soils of the Gwalior district are under the broad group of alluvial soils and medium black soil in patches. Generally the soils of Gwalior district are found in category of low fertility status for nitrogen and medium with respect to phosphorus and potash. Cropping sequences play an important role in sustainable soil health. Leguminous based cropping system; but the information of soil fertility build up/depletion under different cropping system is lacking for the Gwalior districts of M.P. Hence the efforts have been made to study the fertility status in soil of different cropping system of Gwalior district with following objectives:

1. To evaluation of macro and micro nutrients status.
2. Classification of fertility status of sample area (Gwalior district).
3. Soil fertility map generation with respect to major and micro nutrient.

Chapter- II

REVIEW OF LITERATURE

In this chapter ,an attempt has been made to bring out review relating to the **"Soil Fertility Evaluation of Soils of Gwalior District (M.P.)"** A brief resume of the work done in the past by various workers is review under appropriate .

2. Soil fertility condition in India and abroad:

2.1: Soil chemical parameters under different cropping system.

Soil types and nutrient status:

Arora and Takkar (1988) analyzed twenty one Inceptisols and Entisols soil samples from Ludhiana district for physico-chemical characteristics and different forms of S and found that the available -S was positively correlated with EC, OC and fine soil fraction.

Rajkumar *et al.* (1996) observed that Vertisols derived from granite parent material had higher amounts of available Fe and Mn, while those derived from metavolcanic sediments had higher amounts of available Zn and Cu. Alfisols derived from granite parent material had higher amount of Fe, Mn and Zn than those derived from gneiss. The content of available Fe, Mn and Zn correlated significantly and negatively with pH and lime but positively with organic carbon. Available Cu correlated significantly and positively with organic carbon (r=0.43) but negatively with lime (r = -0.34) in paddy growing soils of Karnataka.

Eltaib *et al.* (2002) observed the variability of soil chemical properties such as total N, available P, and exchangeable K on a 1.2 ha rice (*Oryza sativa*) field. The soil (n = 72) samples were systematically taken from individual fields in Sawah Sempadan from thirty-six locations at two depths (0-20 and 20-30 cm). The Differential Global Positioning System (DGPS) was used for locating the sample position. Geo statistical techniques were used to analyze the soil chemical properties variability of the samples that assist in site-specific management of the field. Results showed that areas of similarity were much greater for the soil chemical properties measured at the depth of (0-20 cm) than that of the second lower (20- 30 cm). The ranges of the semi-variogram for total N, available P, and exchangeable K were 12, and 13 m (0-20 cm), 12 and 38 m (20-30 cm), respectively. Point kriging calculated from the semi-variogram was employed for spatial distribution map. The results suggested that soil chemical properties measured may be spatially dependent even within the small area.

Tiwari and Tiwari (2003) reported that increasing dose of sulphur significantly increased the available N, P_2O_5, K_2O and S status in soil after harvest of soybean crop. Super phosphate recorded the highest sulphur uptake by soybean crop. Chaurasia (2009) reported that application of application of 40 Kg S ha^{-1} through single super phosphate recorded the highest sulphur uptake by soybean crop. Maximum available sulphur was recorded in 40 Kg S ha^{-1} through pyrite application after harvest of soybean crop.

Rao *et al.* (2009) Talukdar observed certain elements, which occur in traces in temperate or calcareous soils, are available in excess in humid tropics. Ultisols are low in cat ion exchange capacity, pH and bases and could be characteristically high in Fe, Mn and Cu that are sensitive to pH as well as variable redox potential. Much of agronomic research has centered on applied elements and the role of native elements in plant growth has not been studied in a comprehensive manner. Moreover, relationship between changing soil properties (as governed by climatic variables) and plant growth is a less known aspect. Hence, an investigation was undertaken to study the relationship between temporal changes in soil properties and plant growth. Changes in soil properties and plant volume of test crop i.e. rubber (during high rain fall period) were the inputs in the path analysis. The variables included in the path model explained 58% the variability. The direct and indirect effects of changes in soil properties on growth were distinct and different. Increase in Fe and Mn had significant negative effect on the plant volume (−0.584* and −0.654*, respectively). The path analysis also indicated the nature of interactions among the soil nutrients and organic matter and their ultimate influence on the growth of rubber plant.

Singh *et al.* (2014) conducted a long-term fertilizer experiment on Mollisols (Pantnagar) in order to study crop response, and dynamics and balance of nutrients as one of the objectives. Soil samples were drawn after harvest of wheat of 2010–11, and analyzed for different forms of potassium (K). The apparent and actual K balance was calculated. The results revealed that both rice and wheat responded to applied N since beginning of the experiment, and to P after growing 20 rice-wheat cycles. But so far neither of the crops responded to applied K. Analysis of different forms of K in soil indicated increase in available K with respect to initial level. The change in non-exchangeable K and water soluble K was also noted but was statistically not significant. Apparent K balance study clearly demonstrated negative balance in almost all nutrient management options (control, N, NP, 50% NPK, 100% NPK, 100% NPK+ hand weeding and 150% NPK), except NPK+FYM. However, increase in total K content was found in surface layers in plots that received fertilizer K and FYM compared to fallow plot even after continuous rice-wheat cropping for 40 years. Increase in total K in surface layer ensures that in near future K will not be a limiting factor in crop production on the Mollisols of Pant Nagar.

2.1. a. Soil reaction (pH) and salt content (EC):

Sharma (1992) reported that continuous application of fertilizers to Typic Chromusterts with soybean-wheat-maize crop rotation continuously for 16 years caused a small decrease (0.11dS m^{-1}) in the electrical conductivity (EC) due to application of inorganic fertilizers.

Tembhare *et al*. (1999) found that even after continuous cropping and fertilizer application to Typic haplustert for 24 years period the soil pH and EC (salt concentrate) remain unchanged

Hulugalle *et al*. (1999) noticed that amongst the soil chemical fertility indicators, the soil Ph was not affected consistently by either wheat or field pea.

Santy *et al.* (1999) have also reported that application of FYM and inorganic fertilizer either alone or in combination, to finger millet maize cowpea crop rotation under irrigated tropical garden land condition, had resulted in meager change in E. C. of the soil. The conjoint use of FYM and inorganic fertilizer may cause meager change that could be due to solubilising effect of the decomposition products of the organic manure used on insoluble sources.

Reza *et al.* (2012) determined the degree of spatial variability of pH, organic carbon (OC), available nitrogen (AN) and available potassium (AK) of Goalpara district of Assam. A total of 1397 soil samples from a depth of 0–25 cm at an approximate interval of 1 km were collected over the entire district. Data were analyzed both statistically and geostatistically on the basis of semivariogram. Soil properties showed large variability with greatest variation observed in AK (42%) whereas the smallest variation was in pH (16%). The semivariogram for all soil properties were best fitted by exponential models.

2.1. b. Organic Carbon:

Juma and Gill (1986) reported that long term application of manures increased the organic matter contents in the temperate region as well as in tropics. Long term manure experiments conducted at different location of India indicated.

Bhriguvanshi (1988) observed that the organic carbon status of soil significantly improved by the application of FYM alone or in combination with the nitrogenous fertilizers. There was a marked rise in available p of soil by FYM+N this may be ascribed to the mineralization of organic P with FYM contributing towards its availability same arguments are application for available k content of soil.

Saxena and Chandel (1997) conducted field experiment in U.P. two soybean cultivars were grown with 10.0 kg Zn ha, 1 kg B ha, 1 kg Mo ha and 10 t FYM ha, in the control treatments both cultivars received recommended 20:80:40 kg NPK ha .seed yield were highest in treatment receiving Zn, B, Mo and FYM than the controls.10 kg Zn produced the highest seed yield. This treatment also had the highest value for symbiotic N fixation and organic carbon in soil.

Vijayakumar *et al*. (2011) observed that the ninety six surface soil samples representing twenty villages of the recently tsunami affected areas of

Nagapattinam Taluka of Tamil Nadu in India were analyzed for the basic soil parameters viz., pH, EC, OC and OM. The available micronutrients (DTPA extractable) viz. Fe, Mn, Cu and Zn were investigated by using Atomic Absorption Spectrophotometer (ECIL, AAS-4129). The availability of micronutrients and their relationship with soil properties were also studied. The result showed that the available micronutrients, Fe was found to be sufficient by 97 per cent and Mn deficient by 100 per cent, Zn was found to be sufficient by 53 per cent and Cu deficient by 45 per cent, respectively. Further, Fe showed positive correlation with OC but negative correlation with pH, Mn also followed the same trend as that of Fe with OC, EC and pH, Cu showed positive correlation with EC and negative correlation with pH and OC. Zn showed negative correlation with OC and positive correlation with EC and pH.

2.1c. Available nitrogen:

Sharma and Gupta (1993) reported that the highest build up available N was 255.8 kg ha^{-1} in surface layer after harvest of soybean with incorporation of FYM in combination with inorganic fertilizers as compare to control plots in Typic chromusterts after five successive year of experiment.

Ballakkia and Badanur (1997) reported that the available nitrogen content of surface and sub surface of soils increased significantly than control after the harvest of sorghum by application of FYM (to meet 50% of recommended N) + 50% RDF which could converted that the available nitrogen status in surface layer at the start of the experiment (221 kg ha^{-1}) was found to decrease to 163 kg ha^{-1} in the fallow plots and the decreases was from 221 to 192 kg ha^{-1} in chickpea rotated.

Dixit and Gupta (2000) observed that available nitrogen content increased at post harvest of rice due to combined application of BGA (10 kg ha^{-1}) and FYM (10 tones ha-^{1}) with inorganic fertilizer than control in Inceptisol.

Singh *et al*. (2002) also reported that the available nitrogen, P_2O_5 and K_2O after harvest of upland rice was 106,1,14.0 and 140 kg ha^{-1} respectively. By incorporation of green manure, FYM and Azotobacter. Further, the buildup of available N improved significantly with similar quantity of N (60 kg ha^{-1}) when added in sandy loam soil through urea and FYM as compare to urea alone or urea with BGS (biogas slurry) .after two cycles of rice wheat rotation.

Tomar and Tiwari (2005) carried out an experiment and reported that increasing dose of N, P_2O_5 and K_2O through fertilizer in soil increased the available N, P_2O_5 and K_2O content in soil.

Sharma *et al*. (2008) Observed that the content of available N varied from 63 to 170 kg ha^{-1}, available P from 9.4 to 84.9 kg ha^{-1}, available K from 84 to 700 kg ha^{-1}, and available S from 24.6 to 60.0 kg ha^{-1}, respectively in the soils of Amritsar district of Punjab. A significant positive correlation occurred between organic carbon and N. K. and S.

2.1d. Available phosphorus:

Dubey and shrivastava (1991) reported that the inoculation with *Rhizobium* in the cultivation of soybean reduced the initial available P status of 44.6 kg ha^{-1} to

10.25 and 18.39 kg in the uninoculated and inoculated plots, respectively in Typic Haplistert.

Sharma and Gupta (1993) found that the highest available phosphorus was (29.26 kg ha^{-1}) in surface soil after harvest of soybean, which was received, with incorporation of FYM in combination with inorganic fertilizer.

Dai Rongshu *et al*. (1995) reported that the fertility status of red acid soil was improved by application of P and K fertilizer together with FYM.

Ghosh *et al*. (1998) from their long term studies conducted on a sandy loam alluvial soil with soybean-wheat system also reported that continuous application of phosphate fertilizer resulted in buildup of available P in soil profile, while depletion was observed in treatment where phosphorus was not applied. They have observed that the available P content in control (31.9 kg ha^{-1}) was considerably lower as compared to that in 100% NPK+ FYM treatment (44.2 kg ha^{-1}) after 24 years of crop rotation.

Subbarao *et al.* (1998) observed that the maximum amount of available P (11.05 kg ha^{-1} after soybean and 15.77 kg ha^{-1} after wheat) was recorded either with 8 tone of FYM and 44 kg P ha^{-1} or 16 t of FYM with 22 kg P ha^{-1}

This synergistic effect was due to beneficial role of FYM in arresting P fixation into insoluble forms and keeping it in available from for extended period.

Gupta *et al.* (2000) reported after 2 cycle of rice-wheat rotation in sandy loam soil the status of available soil phosphorus increased under combined application of urea (60 kg N ha^{-1}) with 30 kg P_2O_5 +30 KG K_2O to rice and 60 and 60 kg P_2O_5 +30 kg K_2O ha^{-1} to wheat, as compared to urea alone or conjoint application of FYM and BGS (biogas slurry). Increasing N levels have decreased availability of P.

Dixit and Gupta (2000) reported that in surface layer of Inceptisol at post harvest of rice, the availability phosphorus ranged from 7.24 to 7.52 kg ha^{-1} in treatment of highest fertility level or in the combined application of FYM and BGA.

2.1e. Available potassium:

Dubey and Srivastava (1991) recorded that the K level declined to 193.58 and 300.75 kg ha^{-1} in the uninoculated and inoculated plots; respectively as compared with the initial status of 635.7 kg ha^{-1}.

Agarwal *et al.* (1993) indicated that an increase in available K content with the rate of K application in rice-wheat-cowpea rotation .However significant increases were recorded with 100% NPK and 150%NPK only.

Swarup and Rao (1999) reported that intensive were cropping with high yielding varieties makes a considerable demand on the soil natural resources. Therefore, even the soils, which are currently sufficient in K, may show response to K when higher amounts of N and P are applied.

Dixit and Gupta (2000) recorded the highest available K (195 kg ha^{-} application of FYM and BGA or treatment of highest fertility level of N, P & K (120:60:60) as compared to control.

Swarup and Yadhuvanshi (2000) reported that available P and K increased significantly (16.8 kg ha^{-1}, 262 kg ha^{-1}) and available zinc also (0.92 mg kg^{-1}) by application of NPK (60, 13, 21) with FYM (10 t ha^{-1}).

Singh *et al*. (2000) examine the impact of integrated use of FYM and fertilizer N in soybean-wheat cropping system on soil K status and found that the continuous application of FYM to soybean @ 4, 8 and 16 t ha^{-1} increased NH_4OAc-K from 606 (control) to 618, 653 and 750 kg ha^{-1} and 0.1 M $CaCl_2$-K from 183, 197 and 221 kg ha $^{-1}$ respectively. Application of FYM increased the NH_4OAc and 0.1M $CaCl_2$ extractable K but the reverse was true with the application of fertilizer alone. A declining trend in small quantity was noted in non exchangeable K on application of FYM and nitrogen fertilizer.

Ved Prakash *et al.* (2002) reported that the available K content in the soil after 27 crop cycle of soybean –wheat, showed differential changes, depending on yield response to added fertilizers. In surface layer, the available K remained unchanged under 100% NK and 100% N and FYM treatments, whereas significant build up of K was noticed fewer than 100% NPK +FYM. Significant depletion of available K was observed under control, 100% NP and 100% NPK treatments.

Arora and Chahal (2003) found that available potassium ranged 41.5 to 314.0 mg kg^{-1} in the surface and 32.02 to 243.0 mg kg^{-1} in the surface soil with an average value of 76.0 mg kg^{-1} of the 20 soil series, five were low, fourteen medium and only one high in mean available potassium content.

2.1f. Available sulphur:

Mandal *et al.* (1991) from the experiment on continuous cropping and manuring in a jute-rice-wheat sequence in indo gangetic alluvial soil concluded that the plots receiving sulphur- bearing fertilizer showed higher build up of available sulphur in the plough layer than in sulphur free fertilizer treated plots.

Sharma (1992) reported that the highest build of available N was 20.1 and 21.2 kg ha^{-1} respectively in surface and sub surface soil by application of FYM and crop residue with inorganic fertilizer over eight years was attributed to their beneficial effects on soil physiochemical and microbiological properties. However, the highest sulphur content in all depth of profiles was recorded with application of 110% NPK+FYM as compare to control the

Highest content 40 kg ha^{-1} was recorded in surface layer and progressively decline with increasing depth in Typic Haplustert.

Nambiar *et al.* (1998) reported the loss of productivity due to the continuous application of S free NPK fertilizer. The available sulphur progressively declined with depth and the highest accumulation of available sulphur was noted at the surface.

Trivedi *et al*. (2000) reported that all the forms of sulphur in general decreased with depth and showed significant positive relationship with organic carbon and total nitrogen while the relationship between sulphate sulphur and calcium carbonate content was found significant but negative.

Sharma *et al*. (2008) observed that the content of available N varied from 63 to 170 kg ha^{-1}, available P from 9.4 to 84.9 kg ha^{-1}, available K from 84 to 700 kg ha^{-1}, and available S from 24.6 to 60.0 kg ha^{-1}, respectively in the soils of Amritsar district of Punjab. A significant positive correlation occurred between organic carbon and N. K. and S.

2.1g. Micronutrient:

Singh *et al.* (1995) reported that the Zn deficiency increased with an increase in pH and $CaCO_3$ content and with a decrease in the organic carbon content in soils of arid and semi-arid zone of Punjab.

Sadashiva *et al*. (1995) analyzed the saline-alkali soils of Kabini command area, which showed a significantly positive correlation between the organic carbon content and DTPA-extractable Zn (r =0.559), Fe (r =0.457), Cu (r = 0.722) and Mn (r =0.708). All trace elements decreased with soil depth except available Fe content which was larger in the surface layers. Soil pH was also significantly positively correlated with the DTPA –extractable trace elements.

Dhana and Shukla (1995) reported that the deficiency of Zn and Fe may be expected in a large number of soil series of Maharastra, compared to Zn and Fe deficiency, the deficiency of Mn was limited, while Cu was found to be adequate in all soil series.

Singh *et al*. (1995) reported that the 59, 38, 8 and 2 per cent of soil samples from 9 blocks of Ferozpur district of Punjab were deficient in Zn, Cu, Fe & Mn, respectively.

Thakur (1996) evaluated the DTPA extractable Zn, Cu, and Fe & Mn of the Middl Narmada Valley of Madhya Pradesh and reported that the amount of available Fe, Mn and Cu was sufficient in all soils where as the available Zn status was in the deficient range.

Chattopadhyay *et al*. (1996) observed that the soils in the upper elevation contained more micronutrient cations than the soil on lower elevation in soils of Vindhyanchal scarp lands of Rajasthan. Copper was significantly and negatively correlated with pH, whereas, Fe and Mn showed significantly negative correlation with pH, EC and $CaCO_3$.

Rajkumar *et al.* (1996) observed that Vertisols derived from granite parent material had higher amounts of available Fe and Mn, while those derived from met volcanic sediments had higher amounts of available Zn and Cu. Alfisols derived from granite parent material had higher amount of Fe, Mn and Zn than those derived from gneiss. The content of available Fe, Mn and Zn correlated significantly and negatively with pH and lime but positively with organic carbon. Available Cu correlated significantly and positively with organic carbon (r =0.43) but negatively with lime (r = -0.34) in paddy growing soils of Karnataka.

Saha *et al.* (1996) studied DTPA-extractant Fe, Cu, Mn and Zn in 63 fish pond soils of Orissa in relation to soil characteristics. Available Fe was positively related to organic carbon and available Mn negatively to pH. While available Cu and Zn showed positive correlation with organic carbon. Stepwise multiple regression analysis indicated that the availability of Fe and Mn was mainly controlled by pH that of Cu by organic carbon and Zn by both organic carbon and available P_2O_5 content of the soils.

Pannu *et al*. (1998) reported that the Multiple regression equations showed that 82, 71, 71 and 82 per cent of the variation in Fe, Zn, Cu and Mn availability, respectively were accounted for by the combined effect of soil properties in rice growing soils of Haryana.

Prasad and Gajbhiye (1999) observed that the semi-arid ecosystem provides the status of better Zn supply than sub-humid zone. The soils of semi arid region have lowest available Fe than the soils of sub-humid region. Semi-arid Kanheri soils have higher concentration of Cu than the two other soils occurring in sub-humid climate. Nabibagh soils of sub-humid zone have lowest value of available Mn than the two others soils.

Sharma *et al.* (1999) reported that the coefficients of correlation, DTPA-extractable micro-nutrient content increased with increase in organic carbon and decreased with increase in pH and $CaCO_3$ content in Siwalik hills of the semi arid tract of Punjab.

Singh *et al.* (1999) showed that Cu, Fe and Mn concentration in plants did not have any significant correlation with their content in submerged soils, while the concentration of Zn in plant tissues showed significant positive correlation (r=0.93*) with DTPA-extractable Zn in submerged soil.

Singh and Rao (2001) revealed that Fe, Mn and Zn showed highly significant negative correlation with soil pH where available Cu showed no significant negative correlation. Organic carbon content showed significant positive correlation with available micronutrient in soils in alluvial soils of Kanpur region.

Ibrahim *et al.* (2001) indicated that DTPA extractable micronutrients exhibited a negative correlation with pH, $CaCO_3$ and sand content and positive correlation with organic matter, silt and clay content.

Prabhuraj *et al*. (2001) revealed that availability of Zn and Cu was directly related to the soil organic carbon content. Total Zn, Fe and Mn correlated positively and significantly with CEC of the soil and total Fe with clay content in mulberry growing soils of kirshnarajpet, Karnataka.

Sharma *et al.* (2001a) the DTPA extractable Zn, Cu, Fe and Mn in 14,276 surface soil samples collected from different agro-climatic zones of Madhya Pradesh was studied. Zinc deficiency was maximum in Gird Zone (86.3%) followed by Kymore Plateau and Satpura Hills (68.6), Bundelkhand Zone (65.0%) and Chhattisgarh Plain (63.0%). About 23.7 per cent soils of Satpura plateau, 19.6 per cent of Jhabua Hills, 16.7 per cent of Central

Narmada Valley, 7.2 per cent of Vindhya plateau, 4.9% of Bundelkhand zone and 4.5% of Nimar valley were found to be deficient in Fe. Gird zone showed Mn deficiency to the extent of 12.8 per cent. Available Cu was found sufficient in aIl the zones of the state. Plant (wheat) analysis showed wide spread deficiency of Zn in the whole state. Nearly 81.5 per cent plant samples of Malwa Plateau were found deficient in zinc followed by Vindhyan Plateau (80.3%) and Gird Zone (64.6%). Other zones indicated Zn deficiency below 60 per cent and the minimum being in Satpura Plateau (19.5%). Manganese deficiency in plants was found to the extent of 54.3 per cent in the Gird zone.

Sharma *et al.* (2001b) showed on the basis of experiment conducted at Rajgarh, Madhya Pradesh, the DTPA-Zn and Fe content in soils ranged from 0.02 to 2.18 ppm and from 11.8 to 26.4 ppm respectively. The mean values of soil pH, EC, $CaCO_3$, organic carbon were 7.9, 0.21 dS m^{-1}., 34 and 0.57%, respectively.

Jalali and Sharma (2002) indicated that approximately 24 and 44% of the soils were deficient in available Zn and Fe, respectively. Soil with low organic carbon and high pH were generally low in chelated or complex Zn, Cu, Fe and Mn. The organic carbon, pH and calcium carbonate contents showed significant effect on the availability of these micro-nutrients cat ions.

Sharma *et al.* (2003) reported that zinc, copper, manganese and Iron showed positive correlation with silt plus clay and organic carbon, and negative correlation with silt plus clay and organic carbon, and positive correlation with pH and calcium carbonate content in semi arid regions of Rajasthan.

Patil *et al.* (2003) showed that DTPA-Zn was positive correlated with pH, organic carbon and clay: DTPA-Ca and Mn were positively correlated with Clay: and DTPA-Fe was negatively and significantly correlated with pH, $CaCO_3$, Clay and CEC in shrink soils of Maharashtra.

Sharma *et al.* (2003) showed that Zn, Cu, Fe and Mn were negatively correlated with pH and $CaCO_3$ content in the soils of semi arid region of

Rajathan. Contrary to soil pH, all the fractions of Zn, Fe and Mn were positively correlated with organic carbon.

Sharma *et al*. (2003) evaluated that the Zn, Cu, Fe & Mn showed positive correlation with silt plus clay and organic carbon and negative correlation with pH and calcium carbonate content in Nawa tehsil of Nagaur district in semi-arid region of Rajasthan.

Panwar and Totawat (2004) reported that DTPA extractable Zn, Cu, Fe & Mn ranged from 0.21 to 0.74, 0.27 to 1.04, 1.13 to 4.28 and 2.76 to 7.79 mg kg^{-1}, respectively. The correlation studies showed that there exist a negative correlation between clay, pH and $CaCO_3$ with DTPA extractable metallic cations under study, while a positive correlation was observed between pH and DTPA extractable Cu ($r = 0.83$) and Zn ($r = 0.64$) as well as between $CaCO_3$ and Zn ($r = 0.73$) in salt affected soils of sub humid Southern plains of Rajasthan.

Singh (2004) reported that DTPA extractable Fe, Mn, Cu and Zn decreased down the profile in all the four soil profiles soils in rice soils of Eastern region of Varanasi. Fe and Mn showed positive relationship with pH, EC, organic carbon, clay, CEC and available P_2O_5 content but Cu and Zn were inversely related with soil pH. Zn also showed negative correlation with EC and CEC. Step-down multiple regression analysis indicated that the availability of Cu is dominantly controlled by pH whereas Zn by pH, EC and CEC content of those.

Sharma *et al.* (2004) revealed that the total content of micronutrients increased with an increase in clay and silt. Whereas, DTPA-extractable micronutrient (Zn, Cu, Fe and Mn) increased with an increase in organic carbon content and decreased with increasing pH, sand and calcium carbonate content in Inceptisols of Punjab. The available micronutrient contents depended largely on the organic carbon content.

Verma *et al*. (2007) reported that DTPA extractable Zn, Cu, Fe and Mn ranged from 0.12 to 1.38, 0.06 to 2.12, 2.58 to 16.78 and 1.26 to 11.4 Mg kg^{-1} respectively.

Yadav and Meena (2009) found that the DTPA extractable Zn, Cu, Fe, and Mn in soil sample varied from 0.21 – 2.18, 0.09 -3.05, 0.20 – 18.73 and 0.43-7.57 mg Kg^{-1} respectively.

Vijayakumar *et al*. (2011) observed that the ninety six surface soil samples representing twenty villages of the recently tsunami affected areas of Nagapattinam Taluk of Tamil Nadu in India were analyzed for the basic soil parameters viz., pH, EC, OC and OM. The available micronutrients (DTPA extractable) viz., Fe, Mn, Cu and Zn were investigated by using Atomic Absorption Spectrophotometer (ECIL, AAS-4129). The availability of micronutrients and their relationship with soil properties were also studied. The result showed that the available micronutrients, Fe was found to be sufficient by 97 per cent and Mn deficient by 100 per cent, Zn was found to be sufficient by 53 per cent and Cu deficient by 45 per cent, respectively. Further, Fe showed positive correlation with OC but negative correlation with pH. Mn also followed the same trend as that of Fe with OC, EC and pH. Cu showed positive correlation with EC and negative correlation with pH and OC. Zn showed negative correlation with OC and positive correlation with Ec and pH .

Choudhary *et al*. (2012) found that the available Mn was significant and positively correlated with organic carbon and negatively and significantly correlated with pH, CaCO3

Rajput and Polara (2012) observed that the Bhavnagar district (Gujrat) were high in available DTPA extractable Cu, Fe and Mn and low in Zn. The DTPA – Fe, Mn, Zn, and Cu varied from 2.1 to 20.0, 2.18 to 33.3, 0.07 to 2.12 and 0.04 to 3.12 mg kg^{-1} respectively.

Abir *et al*. (2014) studied adsorption of boron (B) undertaken in 12 soils representing different agro-ecological regions of India revealed that the adsorption of added B was in the order: Vertisols > Inceptisols > Alfisols. Higher the concentration of added B solution, greater was the variability in B adsorption. Soil within each order also differed in B adsorption. Of the three adsorption equations namely, Freundlich, Langmuir and Temkin fitted to the data, Freundlich and Langmuir equations explained the adsorption behaviour of the soils, yet based on prediction coefficients (R^2) Freundlich appeared the best fit for Vertisols and Inceptisols, and Langmuir for Alfisols which showed lowest B adsorption. Freundlich constant ‘a’ and Langmuir constant ‘b’ were positively correlated with free $CaCO_3$, CEC and clay content. Desorption of added B was in the order: Inceptisols > Vertisols > Alfisols. Desorption of B increased with an increase in soil pH, whereas it decreased with an increase in organic C, clay and CEC.

2.2 : Nutrient status in different soils/cropping system :

Trivedi *et al*. (1997) observed that organic carbon, available N, P and S contents of the soil increased under different treatments as compared to their initial status. It was also noted that the increase in organic carbon, available N, P and S contents of soil were greater after the harvest of black gram than mustard.

Verma and Rajput (1999) found that the highest productivity and profitability of Pearl millet -wheat sequence could be sustained when both cropping sequences were fertilized separately with 120 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}

Datt *et al.* (2000) reported that in Tripura soil, available nitrogen varied from high to medium status. A sharp decline from 589 to 522 kg ha^{-1} and 567 to 511 kg ha^{-1} with the rise in shifting cultivation cycle. Available phosphorus was low and varied from 1.05 to 8.02 kg ha. Available potassium varying from low to medium status also showed a decreasing trend from 150 to 125 kg ha^{-1} and 319 to 203 kg ha^{-1} in soils under shifting cultivation.

Sharma and Singh (2001) observed that the available K varied from 90 to 520 kg ha^{-1} and available phosphorus in soils showed a large variation (7 to 55 kg ha^{-1}). Medium and fine textured soils contained higher content of both phosphorus and potassium in the soils of western Rajasthan.

Singh and Singh (2001) studied the effect of fertilizers and FYM in bajra-wheat system and revealed that both bajra and wheat yield continued to increase significantly with increasing levels of N up to 120 kg ha^{-1}. Application of 60 kg K_2O ha^{-1} (over NP) increased the yield of bajra and wheat significantly. Integrating FYM @ 10 t ha^{-1} with NPK sustained higher productivity and uptake of nutrients by the crops.

Varalakshmi *et al*. (2005) conducted an experiment at a farmer’s field on Alfisol to study the effect of different fertilizer recommendation practices on changes in organic carbon, available N, P and K status of the soil and yield of groundnut and finger millet. The highest yield of groundnut and finger millet was obtained when fertilizers were applied as per the package of practices of University of Agricultural Sciences, Bangalore where 100% recommended NPK fertilizers alongwith 7.5 t FYM ha^{-1} were applied. The organic carbon, available N, P and K content of soil were significantly improved with the use of 100% recommended fertilizer + 7.5 t FYM ha^{-1} in groundnut finger millet cropping system.

Meena *et al.* (2006) considering the concept of soil nutrient index, the soils of Tonk district of Rajasthan were found in category of medium fertility status for nitrogen and phosphorus and high with respect to potassium. The value worked out from nutrient index for NPK were 1.75, 1.70 and 2.54 respectively, against the nutrient index values <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status.

Tripathi *et al*. (2007) reported N, P and K status in the hill soils of North-Western Himalayas. The available N-content of the surface soils varies from 142 to 615 kg ha^{-1} this variation may be attributed to the differences in soil properties, crop, and management practices and addition of FYM. The available phosphorus and potassium content varies from 12.0 to 42.6 and 84 to 368 kg ha^{-1} respectively. Forest soils showed higher values of available NPK as compared to the cultivated and pasture scrub land. The average values of N, P and K is agricultural land, forest land and pasture land are 328, 343, 214; 22.4, 25.8, 17.6, and 196, 224 and 162 kg ha^{-1} respectively.

Rao Vara Prasad *et al.* (2008) reported the nutrient status of soils in Ramachandrapuram Mandal of Chittoor district in Andhra Pradesh. The available nitrogen content of surface soil samples varied from 54 to 103 (mean of 110) kg ha^{-1} Low nitrogen status of soil could be attributed to low amount of organic carbon in these soils. The available phosphorus content varied from 9.29 to 23.96 kg ha^{-1}. The soils are medium in available phosphorus. The available potassium content of soil samples varied from 135-320 kg ha^{-1}.

Sharma *et al*. (2008) Observed that the content of available N varied from 63 to 170 kg/ha, available P from 9.4 to 84.9 kg ha^{-1}, available K from 84 to 700 kg ha^{-1}, and available S from 24.6 to 60.0 kg ha^{-1}, respectively in the soils of Amritsar district of Punjab. A significant positive correlation occurred between organic carbon and N. K and S.

Kumar *et al.* (2008) reported that the incorporation of crop residues along with 50% NPK and FYM or GM contributed towards meeting 50% NPK requirement of rice. Long term application of crop residues and organic manures.

Pattanayak *et al.* (2009) reported that the Indian soils have adequate available P, 49.3% are under low category, 48.85 under medium and 1.9% under high category. A soil of Madhya Pradesh was observed in medium category with 1.84 value of nutrient index.

Tandon (2010) reported from the data base of 135000 soil analyses, about 42.3%, Indian soils samples have been found to be deficient or low in available sulphur. Sulphur deficiency is now estimated to be a problem in about 300 districts as compared to 70 districts in 1991.

Kumar and Singh (2010) conducted experiment to assess the direct and residual effect of green manures on crops with and without farmyard manure (FYM). The highest grain and straw yields of rice and wheat were obtained with the application of 100% NPK + green gram + 5 t FYM each year. Combined application of 100% NPK + green gram + 5.0 t FYM each year gave significantly higher available N, P, K and higher content of DTPA-extractable Zn, Fe, Mn and Cu in post-harvest soil at the end of six years cycle.

Chapter- III

MATERIAL AND METHODS

The study entitled **"Soil Fertility Evaluation of Soils of Gwalior District (M.P.)"** was carried out during 2015-16 by the Department of soil science, College of agriculture, Gwalior (M.P.) .This Chapter deal in the following heads.

1 .A general feature of the area under study in respect to:

(a) Location and extent

(b) Agro-ecological region

(c) Topography

(d) Geology

(e) Area

(f) Climate

(g) Hydrology

(h) Soils

(i) Major crops.

2. Collection and preparation of soil samples.

3. Analytical methods employed.

1. A General feature of Gwalior district

(a**) Location and extent:**

The area selected for present investigation i.e. Gwalior district comes under gird region of M.P. which situated between the latitude of 25^0.30' to 26^0.45' north latitudes and longitudes 75^0.30'to 78^0.30' east longitude. The height above means see level varies from 150.15 m to 274.24m having a gradual slope from south-west to north-west to east.

(b) Agro-ecological region:

Agro-ecological region of investigated area is N8D2 (Seghal, 1996)

(c) Topography:

On the basis of morphological observations, slope and other features, soils are well drained. Permeability in the surface as well as sub-surface layer is rapid and it is poor after 100 cm depth due to the cementing effect of calcium carbonate.

(d) Geology:

Geologically the investigated area (Gwalior district) comes under Indo-Gangetic and alluvial plain. Alluvium deposited is an old one as the soil profiles do show horizon differentiation .These alluvial soil have been classified in the US soil taxonomy (soil survey staff,1994) in the following orders and great groups:

Order	Great groups
1. Entisols	Usti,Udi-or Torrifluvents, Haplaquents
2. Inceptisols	Ustochrepts , Haplaquepts
3. Alfisols	Haplustalfs , Natrustalfs

(e) Area:

Gird region of M.P. (Gwalior, Morena and Bhind district) covered 3.74 million hectare area which is 8.46 per cent of the total area of M.P.

(F) Climate:

This region comes under semi arid sub-tropical climate with extreme weather condition having hot and dry summer and cold winter .Generally monsoon sets in during the last week of June. Annual rainfall ranges from 700 to 800 mm, most of which fall during last June to the middle of September. In this area winter rains are occasional and uncertain. The maximum temperature goes upto.47^0 C during summer and minimum as low at 2.8^o C during winter.

(g) Hydrology:

The investigated area is irrigated by canal, wells and tube wells. The main source of irrigation of the area is canal. Apart from this, wells and tube wells are also used for irrigation.

(h) Soils:

Soils of the investigated area are generally variable in color, depending on the timing, period and sources of irrigation system. The profile development varies from undeveloped (A-C) to very well developed (A-Bt-C) profile. Their texture is variable ranging from very coarse to fine. However the soils of the area are deep, alluvium derived soil with medium AWC (available water retention capacity).

i) Major crops:

The major crops of the investigated area are paddy, soybean, jowar and pearl millet in *kharif* and mustard, gram and wheat in *rabi*.

2.0 Collection and preparation of soil samples:

For the present study, 250 surface (0-15 cm) soil samples were collected from four blocks (viz. Morar, Dabra, Bhitarwar and Ghatigoan) of Gwalior district. Location of sampling sites was decided using geo- positioning system. The soil sample were put in the polythene bags, labeled and carried to the laboratory. After collection, the sample were brought to Soil Science laboratory , College of Agriculture , Gwalior and samples were air dried, crushed and sieved through 2 mm plastic sieve. These samples were analysed for different physio- chemical properties, micronutrients and sulphur content, and data were processed statistically to fulfill the proposed objectives.

Table 3 .1: Details of location of farmer's field of Gwalior district:

S.N.	**Block**	**Name of farmer**	**Village**	**Latitude**	**Longitude**
1.	Morar	Jasram	Rai	$26^0$13'34.12''	$78^0$19'54.70''
2.	Morar	Gyasiram	Rai	$26^0$13'35.43''	$78^0$19'41.95''
3.	Morar	Govind Singh	Rai	$26^0$13'44.26''	$78^0$19'41.18''
4.	Morar	Bachchu Singh	Rai	$26^0$13'40.94''	$78^0$19'58.27''
5.	Morar	Jeetharam	Rai	$26^0$13'41.91''	$78^0$19'45.09''
6.	Morar	Harvilash Mahore	Berja	$26^0$13'27.37''	$78^0$21'40.38''
7.	Morar	Heeralal	Berja	$26^0$13'21.17''	$78^0$22'00.21''
8.	Morar	Laturi Prasad	Berja	$26^0$13'29.83''	$78^0$21'50.18''
9.	Morar	Sardar Singh	Berja	$26^0$13'28.68''	$78^0$21'53.91''
10	Morar	Bachchu Singh	Berja	$26^0$13'28.90''	$78^0$21'57.42''
11	Morar	Sardar Singh	Gowai	$26^0$16'26.84''	$78^0$23'10.41''

12	Morar	Ajmer Singh	Gowai	26^{0}16’21.85’’	78^{0}23’14.23’’
13	Morar	Mitthulal	Gowai	26^{0}16’24.67’’	78^{0}23’12.73’’
14	Morar	Sonpal	Gowai	26^{0}16’25.59’’	78^{0}23’17.52’’
15	Morar	Govind Singh	Gowai	26^{0}16’18.47’’	78^{0}23’22.63’’
16	Morar	Vijayram	Susera	26^{0}19’11.85’’	78^{0}09’17.85’’
17	Morar	Sakura Khan	Susera	26^{0}19’12.91’’	78^{0}09’49.06’’
18	Morar	Narayan Baghel	Susera	26^{0}19’23.43’’	78^{0}09’53.37’’
19	Morar	Ramesh Singh	Susera	26^{0}19’26.76’’	78^{0}09’31.38’’
20	Morar	Dharm Singh	Susera	26^{0}19’37.42’’	78^{0}09’23.94’’
21	Morar	Narayan Singh	Susera	26^{0}19’22.33’’	78^{0}09’13.65’’
22	Morar	Laxman Singh	Susera	26^{0}19’24.77’’	78^{0}09’10.56’’
23	Morar	Dyabati Bai	Susera	26^{0}19’27.03’’	78^{0}09’16.23’’
24	Morar	Narayan Singh	Susera	26^{0}19’24.82’’	78^{0}09’17.03’’
25	Morar	Gulliram	Susera	26^{0}19’20.76’’	78^{0}09’10.77’’
26	Morar	Hotam Singh	Supawali	26^{0}14’07.78’’	78^{0}24’03.39’’
27	Morar	Ramesh	Supawali	26^{0}14’08.33’’	78^{0}24’10.70’’
28	Morar	Bhagirath	Supawali	26^{0}14’18.26’’	78^{0}24’08.16’’
29	Morar	Hakim Singh	Supawali	26^{0}14’13.17’’	78^{0}24’05.62’’
30	Morar	Tikaram	Supawali	26^{0}14’09.82’’	78^{0}24’06.36’’
31	Morar	Rambeer Singh	Madanpur	26^{0}15’33.34’’	78^{0}17’04.41’’
32	Morar	Raghubeer Singh	Madanpur	26^{0}15’31.32’’	78^{0}17’04.04’’
33	Morar	Dileep Singh	Madanpur	26^{0}15’33.34’’	78^{0}16’58.73’’
34	Morar	Badri Singh	Madanpur	26^{0}15’35.65’’	78^{0}16’50.73’’
35	Morar	Mulayam Singh	Madanpur	26^{0}15’36.21’’	78^{0}16’56.82’’
36	Morar	Vijayram	Rudrapura	26^{0}13’51.27’’	78^{0}19’18.41’’
37	Morar	Pancham Singh	Rudrapura	26^{0}13’51.48’’	78^{0}19’22.31’’
38	Morar	Laxminarayan	Rudrapura	26^{0}13’57.12’’	78^{0}19’20.52’’

39	Morar	Hari Singh	Rudrapura	$26^0$13’22.50”	$78^0$19’26.9”
40	Morar	Ramdyal	Rudrapura	$26^0$13’56.67”	$78^0$19’11.73”
41	Morar	Patiram	Jalalpur	$26^0$15’54.19”	$78^0$09’34.49”
42	Morar	Ganesha	Jamahar	$26^0$16’06.44”	$78^0$10’10.20”
43	Morar	Dharmedra	Jamahar	$26^0$16’05.30”	$78^0$10’11.20”
44	Morar	Chandan Singh	Jamahar	$26^0$16’12.32”	$78^0$10’17.11”
45	Morar	Rajkumar	Jamahar	$26^0$16’19.21”	$78^0$10’32.04”
46	Morar	Thakur Singh	Milawali	$26^0$18’13.98”	$78^0$06’42.80”
47	Morar	Anjesh	Milawali	$26^0$18’15.02”	$78^0$06’47.31”
48	Morar	Roop Singh	Milawali	$26^0$18’15.76”	$78^0$06’52.91”
49	Morar	Gajraj	Milawali	$26^0$18’16.63”	$78^0$06’57.80”
50	Morar	Ramvaran	Milawali	$26^0$18’19.46”	$78^0$06’58.08”
51	Morar	Kamal	Milawali	$26^0$18’19.89”	$78^0$06’53.30”
52	Morar	Kedar	Milawali	$26^0$18’19.51”	$78^0$06’47.63”
53	Morar	Kamlesh	Milawali	$26^0$18’17.50”	$78^0$06’38.38”
54	Morar	Girraj	Milawali	$26^0$18’01.02”	$78^0$06’58.63”
55	Morar	Kamal	Milawali	$26^0$18’06.24”	$78^0$07’00.19”
56	Morar	Rajbeer	Milawali	$26^0$18’07.75”	$78^0$06’42.54”
57	Morar	Subodh	Milawali	$26^0$18’07.82”	$78^0$06’52.65”
58	Morar	Atar Singh	Khureri	$26^0$15’55.72”	$78^0$15’57.26”
59	Morar	Syam Singh	Khureri	$26^0$15’46.66”	$78^0$15’58.61”
60	Morar	Ramkishan	Khureri	$26^0$15’47.58”	$78^0$15’51.04”
61	Morar	Vasudev	Khureri	$26^0$15’49.74”	$78^0$15’47.51”
62	Morar	Kapoor Singh	Khureri	$26^0$15’55.95”	$78^0$15’88.86”
63	Morar	Gopal Singh	Akabarpur	$26^0$16’13.1”	$78^0$10’10.1”
64	Morar	Hitendra Singh	Akabarpur	$26^0$16’07.8”	$78^0$10’08.0”
65	Morar	Prakash Singh	Akabarpur	$26^0$16’07.5”	$78^0$10’10.4”

66	Morar	Siyaram Singh	Akabarpur	26^{0}16’05.4’’	78^{0}10’15.3’’
67	Morar	Ramswaroop Singh	Akabarpur	26^{0}16’01.7’’	78^{0}10’15.4’’
68	Morar	Simaro Bai	Akabarpur	26^{0}15’58.3’’	78^{0}10’08.7’’
69	Morar	Kalawati	Akabarpur	26^{0}15’56.4’’	78^{0}10’08.0’’
70	Morar	Rajbir Singh	Akabarpur	26^{0}15’53.0’’	78^{0}10’05.5’’
71	Morar	Rambeti	Akabarpur	26^{0}15’53.5’’	78^{0}10’09.7’’
72	Morar	Imarati Devi	Akabarpur	26^{0}15’47.4’’	78^{0}10’10.6’’
73	Morar	Rajesh Singh	Bhadroli	26^{0}15’20.63’’	78^{0}15’50.97’’
74	Morar	Koopi	Bhadroli	26^{0}15’18.36’’	78^{0}1545.34’’
75	Morar	Komal Suresh	Bhadroli	26^{0}15’20.91’’	78^{0}15’45.23’’
76	Morar	Kumbher Singh	Bhadroli	26^{0}17’24.7’’	78^{0}11’26.2’’
77	Morar	Vishwanath Singh	Bhadroli	26^{0}17’20.5’’	78^{0}11’19.0’’
78	Morar	Vishwanath Singh	Bhadroli	26^{0}17’22.7’’	78^{0}11’15.9’’
79	Morar	VeerendraSharma	Khedi	26^{0}14’01.6’’	78^{0}23’24.6’’
80	Morar	RamganeshSharma	Khedi	26^{0}14’03.2’’	78^{0}23’13.5’’
81	Morar	Rameshwar-Dayal	Khedi	26^{0}14’00.6’’	78^{0}23’31.3’’
82	Morar	Ravi Sharma	Khedi	26^{0}14’00.6’’	78^{0}23’31.3’’
83	Morar	Bala Bai	Khedi	26^{0}14’04.9’’	78^{0}23’17.7’’
84	Morar	RamlaxamanSharma	Ikhara	26^{0}13’58.0’’	78^{0}23’18.9’’
85	Morar	Veerendra Sharma	Ikhara	26^{0}13’57.8’’	78^{0}23’09.7’’
86	Morar	Ramendra Sharma	Ikhara	26^{0}13’54.0’’	78^{0}23’12.6’’
87	Morar	Fool Singh Mahore	Ikhara	26^{0}13’31.4’’	78^{0}23’40.3’’
88	Morar	Neeraj Sharma	Ikhara	26^{0}13’20.4’’	78^{0}23’40.3’’
89	Morar	Manju Sharma	Ikhara	26^{0}13’36.4’’	78^{0}23’38.4’’
90	Morar	Ram Singh	Ikhara	26^{0}13’18.4’’	78^{0}23’42.6’’
91	Dabra	Rajkumar	Pthapanihar	25^{0}57’11.58’’	78^{0}18’58.72’’
92	Dabra	Sabailal	Pthapanihar	25^{0}57’07.17’’	78^{0}19’14.88’’

93	Dabra	Kalyan Singh	Pthapanihar	25^{0}57’09.76’’	78^{0}19’12.26’’
94	Dabra	Nirbhay Singh	PthaPanihar	25^{0}57’10.62’’	78^{0}19’02.46’’
95	Dabra	Krpal Kaur	PthaPanihar	25^{0}57’12.83’’	78^{0}19’18.50’’
96	Dabra	Hari Singh	Simariya	25^{0}54’55.07’’	78^{0}18’38.40
97	Dabra	Felomeen	Simariya	25^{0}54’55.77’’	78^{0}18’36.94”
98	Dabra	Anil Sadana	Simariya	25^{0}54’57.70’’	78^{0}18’40.82”
99	Dabra	Arun Jain	Simariya	25^{0}54’59.29’’	78^{0}18’39.85”
100	Dabra	Badan Sigh	Simariya	25^{0}54’57.84’’	78^{0}18’37.21”
101	Dabra	Ramshree Bai	Akabai-Badi	25^{0}58’28.68’’	78^{0}20’02.26”
102	Dabra	Kishan Sharma	Akabai-Badi	25^{0}58’25.71’’	78^{0}20’01.44”
103	Dabra	Lakhan Lal	Akabai-Badi	25^{0}58’23.00’’	78^{0}19’57.40”
104	Dabra	Veerendra Sharma	Akabai-Badi	25^{0}58’31.84’’	78^{0}20’00.93”
105	Dabra	RavindraSharma	Akabai-badi	25^{0}58’27.59’’	78^{0}20’10.05”
106	Dabra	Kelash Yadav	Salaiya	25^{0}59’58.39’’	78^{0}21’10.41”
107	Dabra	Amar Singh	Salaiya	25^{0}59’57.13’’	78^{0}21’14.52”
108	Dabra	Raj Singh	Salaiya	25^{0}59’54.55’’	78^{0}21’13.90”
109	Dabra	Ramdei Bai	Salaiya	25^{0}59’51.21’’	78^{0}21’15.42”
110	Dabra	Devi Singh	Salaiya	25^{0}59’49.45’’	78^{0}21’08.83”
111	Dabra	Rambati Bai	masudpur	25^{0}59’54.94’’	78^{0}20’00.91”
112	Dabra	Prem Singh	masudpur	25^{0}59’55.08’’	78^{0}19’56.30”
113	Dabra	Omprkash	masudpur	25^{0}59’50.69’’	78^{0}19’57.10”
114	Dabra	Laxman Singh	masudpur	25^{0}59’55.66’’	78^{0}19’53.53”
115	Dabra	Kundan Singh	masudpur	25^{0}59’52.22’’	78^{0}20’05.39”
116	Dabra	Vilasiram	samudan	25^{0}57’46.05’’	78^{0}18’24.62”
117	Dabra	Ram Singh	samudan	25^{0}57’47.17’’	78^{0}18’26.92”
118	Dabra	Rattan Singh	samudan	25^{0}57’43.01’’	78^{0}18’29.69”

119	Dabra	Pehalvan Singh	samudan	$25^0$57’43.76’’	$78^0$18’19.96”
120	Dabra	Lal Singh	samudan	$25^0$57’51.19’’	$78^0$18’28.16”
121	Bhitarwar	Rajendra Singh	Kachaua	$26^0$00’28.03’’	$78^0$10’25.44’’
122	Bhitarwar	Machal Singh	Kachaua	$26^0$00’31.38’’	$78^0$10’21.96’’
123	Bhitarwar	BhoopendraSingh	Kachaua	$26^0$00’36.02’’	$78^0$10’29.95’’
124	Bhitarwar	Gajendra Singh	Kachaua	$26^0$00’31.91’’	$78^0$10’34.00’’
125	Bhitarwar	Raju Singh	Kachaua	$26^0$00’38.02’’	$78^0$10’56.28’’
126	Bhitarwar	Veerendra Singh	Antri	$26^0$03’35.80’’	$78^0$12’37.55’’
127	Bhitarwar	Bholaram	Antri	$26^0$03’32.99’’	$78^0$12’39.92’’
128	Bhitarwar	Karan Singh	Antri	$26^0$03’36.74’’	$78^0$12’38.54’’
129	Bhitarwar	Ramsingh	Antri	$26^0$03’31.40’’	$78^0$12’41.56’’
130	Bhitarwar	Gambheer Singh	Antri	$26^0$03’31.44’’	$78^0$12’34.14’’
131	Bhitarwar	Gajendra Singh	Pipraua	$25^0$59’19.74’’	$78^0$05’43.62’’
132	Bhitarwar	Dheeraj Singh	Pipraua	$25^0$59’18.41’’	$78^0$05’34.78’’
133	Bhitarwar	Chhatrapal	Pipraua	$25^0$59’28.62’’	$78^0$05’32.95’’
134	Bhitarwar	Guljari Singh	Pipraua	$25^0$59’33.11’’	$78^0$05’39.04’’
135	Bhitarwar	Maniram	Pipraua	$25^0$59’18.09’’	$78^0$05’48.88’’
136	Bhitarwar	Kamal Singh	Prempur	$26^0$00’12.99’’	$78^0$08’28.90’’
137	Bhitarwar	Ramavtar	Prempur	$26^0$00’02.19’’	$78^0$08’09.92’’
138	Bhitarwar	Kaptan Singh	Prempur	$26^0$00’02.79’’	$78^0$08’45.82’’
139	Bhitarwar	Ayodhya Prasad	Prempur	$26^0$00’04.00’’	$78^0$08’32.94’’
140	Bhitarwar	Mohan Singh	Prempur	$26^0$00’15.08’’	$78^0$08’04.63’’
141	Bhitarwar	Sukhvindar Singh	Bdagisaray	$25^0$58’19.70’’	$78^0$11’12.56’’
142	Bhitarwar	Kasmir Singh	Bdagisaray	$25^0$58’11.51’’	$78^0$11’00.08’’
143	Bhitarwar	Ram Singh	Bdagisaray	$25^0$58’30.11’’	$78^0$10’36.56’’
144	Bhitarwar	Gurvindar Singh	Bdagisaray	$25^0$58’51.73’’	$78^0$11’03.57’’
145	Bhitarwar	Ranjeet Singh	Bdagisaray	$25^0$58’20.00’’	$78^0$11’20.64’’

146	Bhitarwar	OmprakashYadav	Shivnagar	26^{0}02’41.20’’	78^{0}08’06.20’’
147	Bhitarwar	Rajendra Yadav	Shivnagar	26^{0}02’37.90’’	78^{0}08’03.20’’
148	Bhitarwar	TituriyaSinghYadav	Shivnagar	26^{0}02’47.50’’	78^{0}08’05.00’’
149	Bhitarwar	Kaptan Singh	Shivnagar	26^{0}02’43.60’’	78^{0}08’01.90’’
150	Bhitarwar	Omprakash Yadav	Shivnagar	26^{0}02’44.00’	78^{0}08’05.70’’
151	Bhitarwar	Dinesh Kushwah	Amrol	26^{0}02’12.20’	78^{0}08’28.00’’
152	Bhitarwar	Virendra Rawat	Amrol	26^{0}02’15.60’	78^{0}08’14.40’’
153	Bhitarwar	Narayan Singh	Amrol	26^{0}02’10.80’	78^{0}08’30.60’’
154	Bhitarwar	Pancham Singh	Amrol	26^{0}01’13.2’’	78^{0}08’21.4’’
155	Bhitarwar	Narendra Singh	Amrol	26^{0}01’17.1’’	78^{0}08’24.9’’
156	Bhitarwar	Arjun Singh	Amrol	26^{0}01’12.4’’	78^{0}07’45.2’’
157	Bhitarwar	Madan Singh	Amrol	26^{0}01’20.8’’	78^{0}07’36.9’’
158	Bhitarwar	Niranjan Singh	Amrol	26^{0}01’21.2’’	78^{0}07’36.7’’
159	Bhitarwar	Bhikam Singh	Amrol	26^{0}00’19.0’’	78^{0}07’14.1’’
160	Bhitarwar	Dinesh Kushwah	Amrol	26^{0}00’17.3’’	78^{0}07’18.7’’
161	Bhitarwar	Chhanno Bai	Amrol	26^{0}00’15.9’’	78^{0}07’11.0’’
162	Bhitarwar	Ramhit	Amrol	26^{0}01’39.9’’	78^{0}07’17.2’’
163	Bhitarwar	Puran	Amrol	26^{0}01’53.7’’	78^{0}08’01.8’’
164	Bhitarwar	Virendra Rawat	Amrol	26^{0}01’52.2’’	78^{0}06’08.0’’
165	Bhitarwar	Munni Bai	Nikodi	26^{0}02’34.2’’	78^{0}06’29.0’’
166	Bhitarwar	Uday Singh	Nikodi	26^{0}02’33.0’’	78^{0}06’25.1’’
167	Bhitarwar	Badam Singh	Nikodi	26^{0}02’26.2’’	78^{0}06’21.1’’
168	Bhitarwar	Ramesh	Nikodi	26^{0}02’30.1’’	78^{0}06’15.7’’
169	Bhitarwar	Mahendra Singh	Nikodi	26^{0}02’08.7’’	78^{0}06’11.1’’
170	Bhitarwar	Pukho Bai	Nikodi	26^{0}02’06.4’’	78^{0}06’03.1’’
171	Bhitarwar	Dalweer Singh	Nikodi	26^{0}02’07.2’’	78^{0}06’00.2’’
172	Bhitarwar	Gangaram	Nikodi	26^{0}02’00.7’’	78^{0}06’00.7’’

173	Bhitarwar	Pooran Singh	Nikodi	$26^0$01’55.2’’	$78^0$06’01.1’’
174	Bhitarwar	Punjab Singh	Nikodi	$26^0$02’04.9’’	$78^0$06’07.2’’
175	Bhitarwar	Om Prakash Singh	Nikodi	$26^0$02’07.3’’	$78^0$06’00.2’’
176	Bhitarwar	Hameer Singh	Nikodi	$26^0$02’19.8’’	$78^0$06’15.9’’
177	Bhitarwar	Munni Bai	Nikodi	$26^0$02’21.2’’	$78^0$06’13.3’’
178	Bhitarwar	Girraj/Mansingh	Nikodi	$26^0$02’21.9’’	$78^0$06’31.6’’
179	Bhitarwar	Jas Ram /Vijay	Nikodi	$26^0$02’26.4’’	$78^0$06’28.8’’
180	Bhitarwar	Girraj Singh	Nikodi	$26^0$02’25.1’’	$78^0$06’33.1’’
181	Bhitarwar	Brij Mohan	Nikodi	$26^0$02’09.4’’	$78^0$06’38.4’’
182	Bhitarwar	Mahendra Singh	Nikodi	$26^0$02’09.6’’	$78^0$06’40.6’’
183	Bhitarwar	Jasram Singh	Nikodi	$26^0$02’05.5’’	$78^0$06’45.9’’
184	Bhitarwar	Munshi Singh	Nikodi	$26^0$02’06.5’’	$78^0$06’35.2’’
185	Bhitarwar	Balveer Singh	Nikodi	$26^0$02’21.7’’	$78^0$06’40.1’’
186	Bhitarwar	Narendra Singh	Nikodi	$26^0$02’27.1’’	$78^0$06’40.2’’
187	Bhitarwar	Mahendra Singh	Nikodi	$26^0$02’27.6’’	$78^0$06’44.8’’
188	Bhitarwar	Hameer Singh	Nikodi	$26^0$02’29.0’’	$78^0$06’43.5’’
189	Bhitarwar	Gambhir Singh	Nikodi	$26^0$02’39.9’’	$78^0$06’39.1’’
190	Bhitarwar	Shrilal	Nikodi	$26^0$02’44.0’’	$78^0$06’35.8’’
191	Bhitarwar	Dalbir Singh	Nikodi	$26^0$02’41.9’’	$78^0$06’28.9’’
192	Bhitarwar	Ramesh Singh	Nikodi	$26^0$02’41.0’’	$78^0$06’20.9’’
193	Bhitarwar	Ajab Singh	Nikodi	$26^0$02’34.4’’	$78^0$06’09.7’’
194	Bhitarwar	Omprakash Singh	Nikodi	$26^0$02’36.0’’	$78^0$06’06.8’’
195	Bhitarwar	Jaswant Singh	Nikodi	$26^0$02’38.9’’	$78^0$06’16.0’’
196	Bhitarwar	Uttam Singh	Nikodi	$26^0$02’40.4’’	$78^0$06’23.3’’
197	Bhitarwar	Gobardhan	Nikodi	$26^0$02’39.9’’	$78^0$06’23.3’’
198	Bhitarwar	Baldeo Singh	Mauch	$26^0$02’46.1’’	$78^0$06’58.6’’
199	Bhitarwar	Kuber Singh	Mauch	$26^0$02’51.1’’	$78^0$06’52.7’’

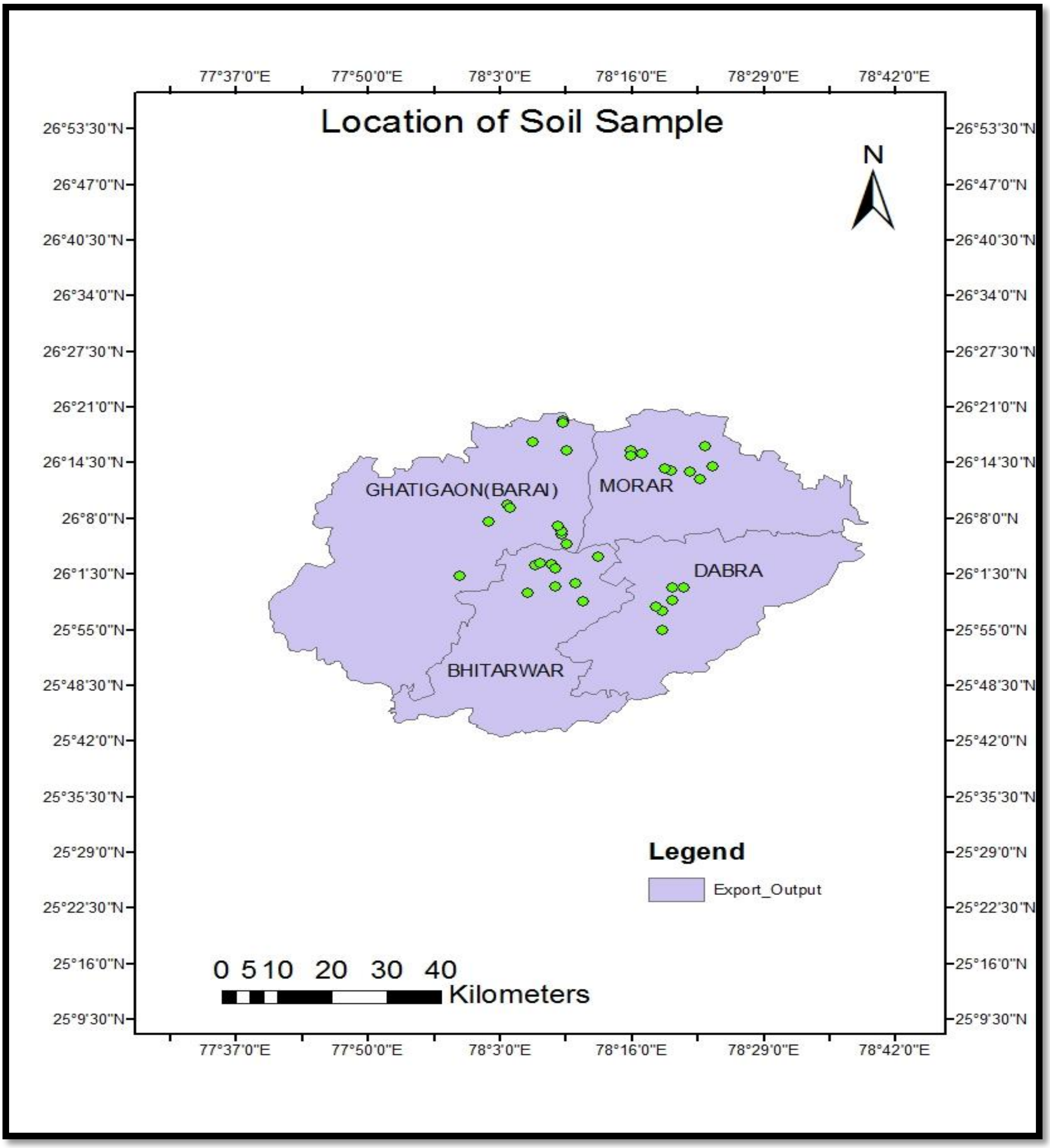
200	Bhitarwar	Maniram	Mauch	26^{0}02’48.2’’	78^{0}05’52.8’’
201	Ghatigaon	Babulal Baghel	Raipur khurd	26^{0}09’13.43’	78^{0}04’04.40’’
202	Ghatigaon	Lotan Singh	Raipur khurd	26^{0}09’18.90’	78^{0}06’08.25’’
203	Ghatigaon	Lakhan Baghel	Raipu rkhurd	26^{0}09’53.84’’	78^{0}04’39.07’’
204	Ghatigaon	Ramadhar	Raipur khurd	26^{0}08’11.81’’	78^{0}05’07.88’’
205	Ghatigaon	Bhagban singh	Raipur khurd	26^{0}08’36.62’’	78^{0}04’44.14’’
206	Ghatigaon	Ramswarup	kanser	26^{0}02’03.82’’	77^{0}38’40.52’’
207	Ghatigaon	Angna	kanser	26^{0}02’21.07’’	77^{0}40’12.88’’
208	Ghatigaon	Prem adiwasi	kanser	26^{0}03’0.32’’	77^{0}40’15.18’’
209	Ghatigaon	Patram	kanser	26^{0}02’10.21’’	77^{0}39’21.58’’
210	Ghatigaon	Mahesh Gurjar	Kanser	26^{0}03’08.63’’	77^{0}39’57.30’’
211	Ghatigaon	Lakhansingh Gurjar	Raipur kla	26^{0}09’04.52’’	78^{0}03’49.63’’
212	Ghatigaon	Balramsingh gurjar	Raipur kla	26^{0}09’36.10’’	78^{0}03’51.80’’
213	Ghatigaon	Gajendra singh	Raipur kla	26^{0}09’30.13’’	78^{0}04’53.86’’
214	Ghatigaon	Chandrabhan	Raipur kla	26^{0}09’05.04’’	78^{0}05’34.55’’
215	Ghatigaon	Ramswarup Kushwh	Raipur kla	26^{0}08’54.52’’	78^{0}04’52.70’’
216	Ghatigaon	Sitaram Kaurav	Barai	26^{0}07’39.5’’	78^{0}01’55.5’’
217	Ghatigaon	Nabab Singh	Barai	26^{0}07’38.8’’	78^{0}01’17.2’’
218	Ghatigaon	ShriMatiKamla Bai	Barai	26^{0}07’39.5’’	78^{0}01’49.3’’
219	Ghatigaon	Devi Singh	Barai	26^{0}07’42.9’’	78^{0}01’11.4’’
220	Ghatigaon	Ramadhar	Barai	26^{0}07’37.4’’	78^{0}01’49.8’’
221	Ghatigaon	Jitendra	Jigsoli	26^{0}16’57.59’’	78^{0}06’17.19’’
222	Ghatigaon	Monu	Jigsoli	26^{0}16’59.37’’	78^{0}06’07.60’’
223	Ghatigaon	Shalendra	Jigsoli	26^{0}16’56.27’’	78^{0}06’14.72’’
224	Ghatigaon	Satish	Jigsoli	26^{0}16’51.13’	78^{0}06’16.52’’
225	Ghatigaon	Irbhan Khan	Jigsoli	26^{0}16’53.88’’	78^{0}06’22.45’’
226	Ghatigaon	Rajendra Singh	Khushrajpur	26^{0}05’02.78’’	78^{0}09’37.49’’

227	Ghatigaon	Lakhan Singh	Khushrajpur	26^{0}04’56.45’’	78^{0}10’48.77’’
228	Ghatigaon	Karan Singh	Khushrajpur	26^{0}05’34.91’’	78^{0}10’20.95’’
229	Ghatigaon	Nihal Singh	Khushrajpur	26^{0}05’50.47’’	78^{0}09’26.01’’
230	Ghatigaon	Divan Singh	Khushrajpur	26^{0}05’25.53’’	78^{0}08’58.45’’
231	Ghatigaon	Narayan Singh	Khushrajpur	26^{0}05’17.43’’	78^{0}11’18.42’’
232	Ghatigaon	Ramcharan Singh	Khushrajpur	26^{0}04’50.25’’	78^{0}08’51.99’’
233	Ghatigaon	Babu Singh	Khushrajpur	26^{0}06’03.7’’	78^{0}09’07.7’’
234	Ghatigaon	Uday Singh	Khushrajpur	26^{0}06’02.5’’	78^{0}09’04.4’’
235	Ghatigaon	Prem Singh	Khushrajpur	26^{0}06’02.2’’	78^{0}09’15.8’’
236	Ghatigaon	Harmohan	Khushrajpur	26^{0}06’27.6’’	78^{0}09’04.9’’
237	Ghatigaon	Rambaran	Khushrajpur	26^{0}06’27.6’’	78^{0}09’04.4’’
238	Ghatigaon	Sultan Singh	Khushrajpur	26^{0}06’20.46’’	78^{0}08’40.68’’
239	Ghatigaon	Sardar Singh	Khushrajpur	26^{0}06’21.42’’	78^{0}09’18.04’’
240	Ghatigaon	Mangal Singh	Khushrajpur	26^{0}06’32.52’	78^{0}08’39.61’’
241	Ghatigaon	Rajendra Singh	Khushrajpur	26^{0}06’40.14’’	78^{0}09’23.34’’
242	Ghatigaon	Gita Bai	Kheriyakachai	26^{0}07’11.0’’	78^{0}08’39.9’’
243	Ghatigaon	Ummed Singh	Kheriyakachhai	26^{0}07’14.9’’	78^{0}08’45.3’’
244	Ghatigaon	Babu Singh	Kheriyakachhai	26^{0}07’22.7’’	78^{0}08’47.8’’
245	Ghatigaon	Ramjet Baghel	Kheriyakachhai	26^{0}07’19.4’’	78^{0}08’50.0’’
246	Ghatigaon	Mewa Ram	Kheriyakachhai	26^{0}07’58.5’’	78^{0}08’36.7’’
247	Ghatigaon	Firoz	Kheriyakachhai	26^{0}07’58.4’’	78^{0}08’34.2’’
248	Ghatigaon	Diwan Singh	Kheriya K.	26^{0}07’56.2’’	78^{0}08’35.4’’
249	Ghatigaon	Mangal Singh	Kheriyakachhai	26^{0}07’02.6’’	78^{0}08’38.8’’
250	Ghatigaon	Mahendra Singh	Kheriyakachhai	26^{0}07’12.0’’	78^{0}08’40.8’’

.Table 3.2 **Numbers of samples collected from different blocks:**

Blocks	Morar	Dabra	Bhitarwar	Ghatigaon
No. of soil samples	90	30	80	50

Fig. 3.1 Location map of study area:



3.0 Analytical methods employed in the soil analysis:

Chemical analysis:

1. pH:

The soil pH was determined by glass electrodes in 1:2 soil water suspensions (Piper, 1967).

2. Electrical conductivity (EC):

The soil water suspension used for pH determination was allowed to settle down and conductivity of the supernatant liquid was determined by Conductivity Bridge.

3. Organic carbon:

Organic carbon was estimated by the walkley-Black (1934) method . In this method organic matter in the soil is oxidized with a mixture of potassium dichromate ($k_2cr_2O_7$) and concentrated H_2SO_4 utilizing the heat of dilution of H_2S0_4. Unused $k_2cr_2O_7$ is back titrated with ferrous ammonium sulphate.

4. Determination of available Nitrogen:

Available nitrogen was determined by the alkaline permanganate method (Subbiah and Asija, 1956).

In this method 5 g. of soil in a digestion tube and add little water.Now add 20 ml. of 0.32% $KMnO_4$ solution to the sample and fit the tube in the distillation unit. Add 20 ml of 2.5% NaOH solution through the distyl-em –dosing pump.Pipette out 20 ml. of 2.5% of boric acid in a conical flask and clip the receiving end of the distyl-em in it. Distil ammonia gas from the tube and collect in the received acid. Now add 5 drops of mixed indicator and titrate with 0.02N H_2SO_4. Blank correction (without soil) is to be made for final calculations.

5. Determination of available Phosphorus:

Available phosphorus in the soil was determined calorimetrically by Olsen's method (Olsen *et al.* 1954).

Extraction:

2.5 g of the soil sample was shaken with 50 ml of 0.5M $NaHCO_3$ (adjusted to pH 8.5) as an extractant together with 1g of darco G-60 (Free from soluble phosphorus) for 30 minutes in 100 ml ,conical flask on mechanical shaker and then filtered through filter paper .

Development of colour:

5 ml of the colorless filtrate was taken in 25 ml volumetric flask for determination and then 5 ml of ammonium molybdate hydrochloric acid solution was added. The contents were diluted to about 10 ml with distilled water, shaken and then 1ml of working solution of stannous chloride was added to develop blue colour and diluted to the mark, and shaken thoroughly. The colour intensity was measured in photo-electric colorimeter at 660 nm wavelength. The amount of available phosphorus was calculated as P and the results were expressed in kg ha^{-1}

6. Determination of available potassium:

Five gram of soil was shaken with 25ml of neutral normal ammonium acetate solution as an extracting in 100 ml conical flask for 5 minutes and then filtered through filter paper. The potassium content in the extracts was estimated by Flame photometer (Jackson, 1973).

7. Available sulphur in soil:

Available sulphur in soil was determined by turbidimetric method after extracting the soil with 0.15% $CaCl_2$ solution as described by (Chesnin and Yien, 1951).

8. Available Iron, Manganese, Copper, Zinc (DTPA Extractable):

Available Fe, Mn, Cu and Zn were determined by Atomic Absorption Spectrophotometer using 0.005 M DTPA (Diethylene Triamine Penta Acetic Acid) as an extractant proposed by Lindsay and Norvell (1978).

This method consisted of shaking a few grams of soil with a buffered solution, containing DTPA (Diethylene Triamine Penta Acetic Acid). This chemical acts as a mild chelating agent, which extracts the easily soluble zinc, iron, copper and manganese. The extracting solution is buffered at pH 7.3 by

Triethnolamine (TEA), and in addition, includes calcium chloride to prevent the dissolution of calcium carbonate. These conditions permit the right amount of zinc, iron, copper and manganese to be dissolved and $CaCl_2$ is to stabilize the pH of the extractant.

The dissolved elements in the extract are, then measured by the atomic absorption spectrophotometer, where in, the extracted sample is converted first into an atomic vapour, usually by a flame and irradiated by the metal being sought, the absorption of the light by the vaporized samples is related to the concentration of the derived metal in it.

DTPA extracting solution:

1. 0.005 M DTPA ($C_{14}H_{23}N_3O_{10}$)
2. 0.01 M Calcium chloride ($CaCl_2$ $2H_2O$)
3. 0.1 M Triethanol amine ($C_5H_{15}NO_3$)

In order to prepare 0.005 M DTPA solution, 74.6 ml of TEA, 9.84 g of DTPA and 7.35 g of Calcium chloride were taken in approximately 200 ml distilled (double distilled) water and allowed sufficient time for DTPA to dissolve. The solution was diluted to about 4.5 liters. The pH of the solution was adjusted to 7.3 using of 1 N Hydrochloric acid. The volume was then made upto 5 litre.

Procedure

Weighed 10 gram soil into a 100 ml polyethylene flask and added 20 ml DTPA solution, shacked for 2 hours in mechanical shaker. The suspension was filtered through a Whatman no. 42 filter paper in to a suitable plastic bottles and Zn, Cu; Fe & Mn were determined by Atomic Absorption Spectrophotometer.

Standard solution for Zn, Cu, Fe & Mn:

DTPA extraction for micronutrients observations:

1. Weight of soil taken = 12.5 gm
2. Volume of DTPA extract made = 25 ml
3. Digital reading or reading on the galvanometer = T
4. Concentration (ppm) of heavy metal as read = C

From the standard curve against T for sample

5. Concentration of heavy metal in the blank solution = cb

Calculation

1. Dilution factor = 25/ 12.5

2. Now available heavy metal in the soil (ppm) = (C- cb) x 2

Table 3.3: Reading for copper standards taken from Atomic absorption spectrophotometer

S. No.	Concentration of copper (mg L^{-1})	Absorbency
1.	0.000	-0.002
2.	1.000	0.9708
3.	1.500	1.6137
4.	2.000	1.7372

Fig 3.2: Standard Curve for available Cu

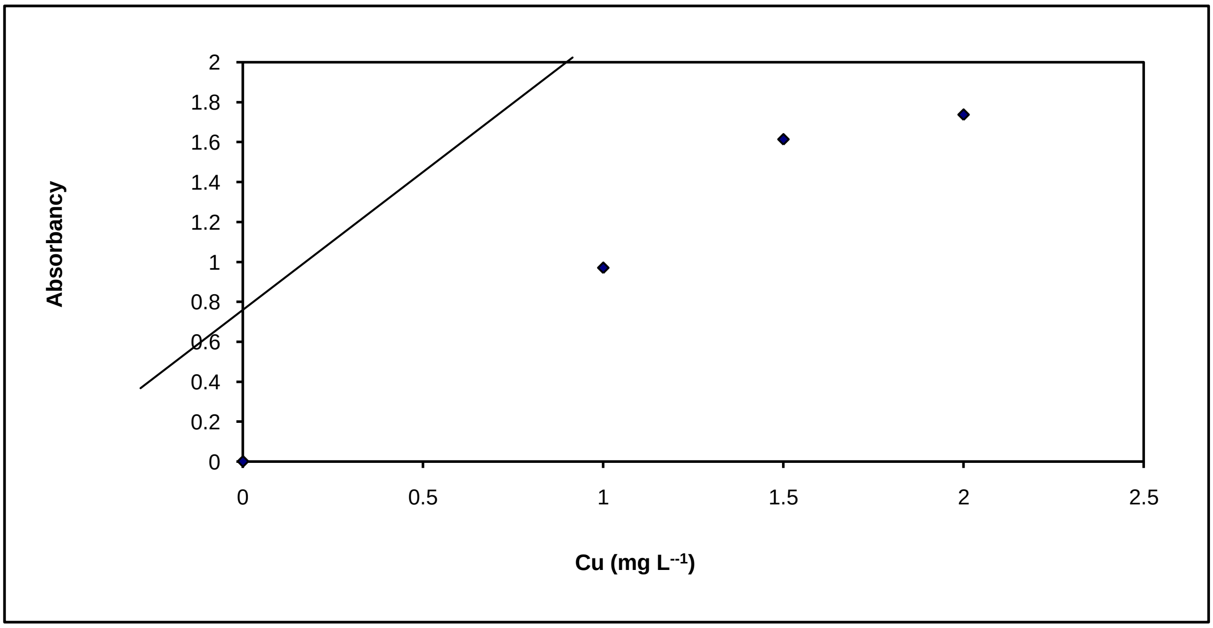


Table 3.4: Reading for zinc standards taken for atomic absorption spectrophotometer

S. No.	Concentration of zinc (mg L^{-1})	Absorbency
1.	0.000	-0.0002
2.	0.500	0.2318
3.	1.000	0.3763
4.	1.500	0.4365

Fig 3.3: Standard Curve for available Zn

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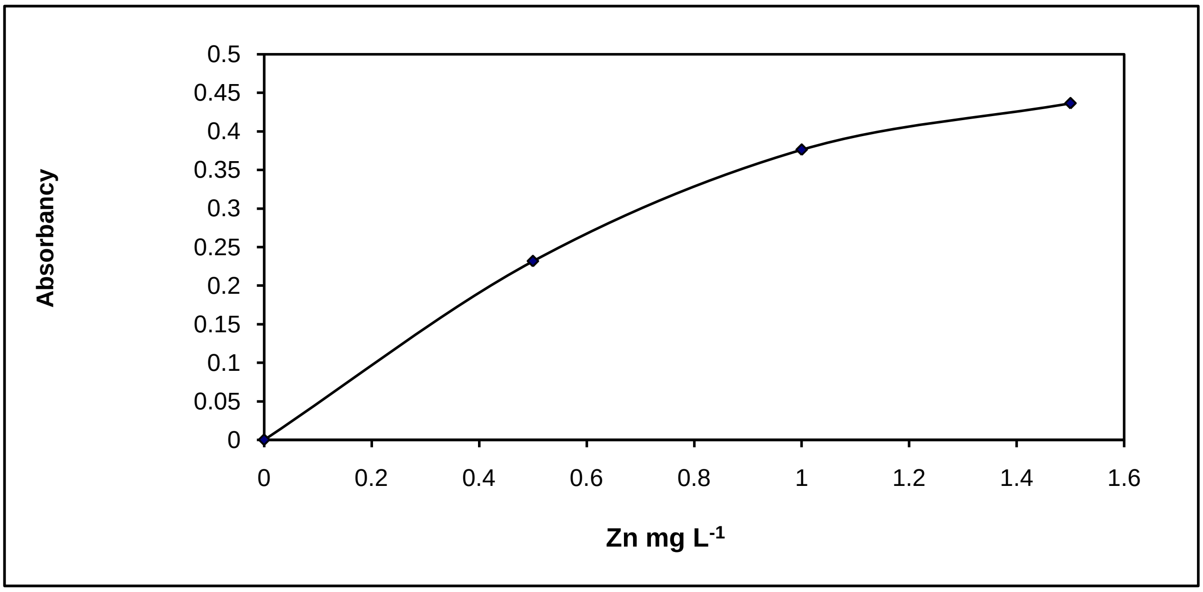


Table 3.5: Reading for manganese (Mn) standards taken for atomic absorption spectrophotometer

S. No.	Concentration of Mn (mg L^{-1})	Absorbency
1.	0.000	0.000
2.	1.000	0.8704
3.	1.5000	1.6520
4.	2.000	2.3372

Fig 3.4: Standard Curve for available Mn:

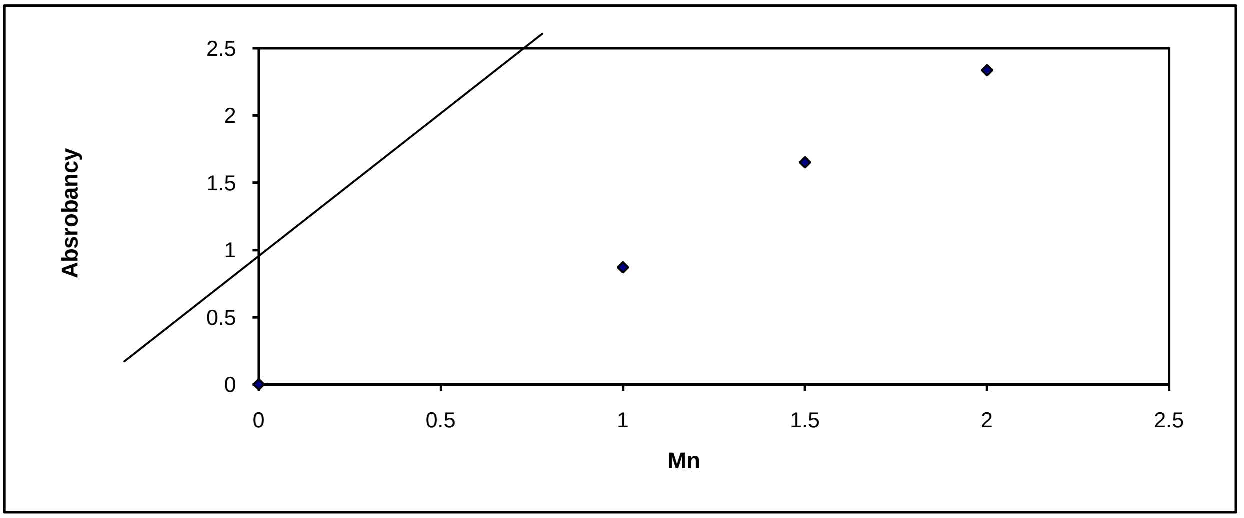
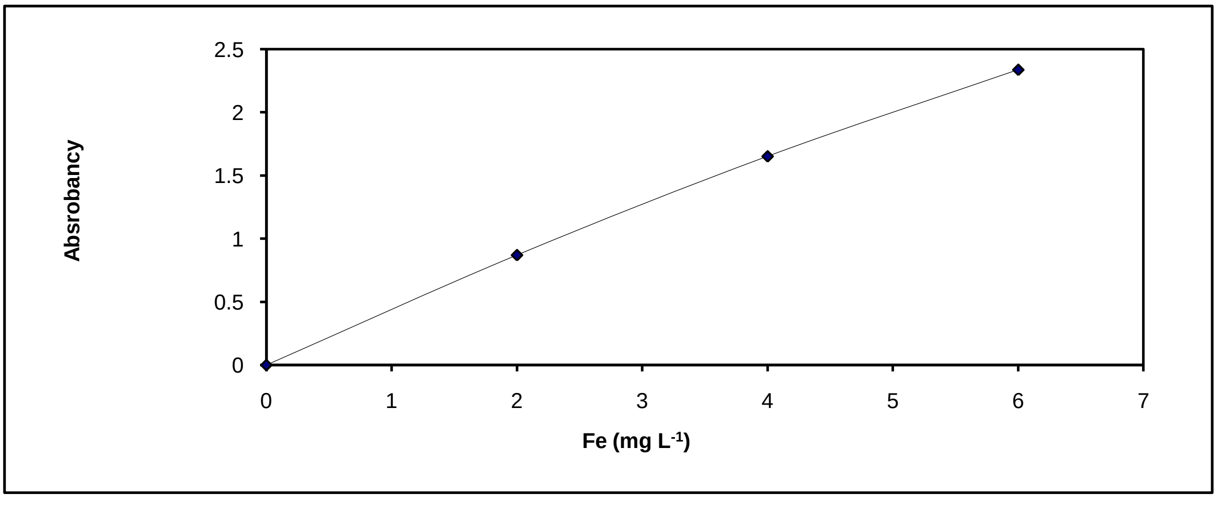


Table 3.6: Reading for Iron (Fe) standards taken for atomic absorption spectrophotometer

S. No.	Concentration of Fe (mg L^{-1})	Absorbency
1.	0.000	0.000
2.	2.000	0.2520
3.	4.000	0.4110
4.	6.000	0.5876

Fig 3.5: Standard Curve for available Fe



9. Available boron

The hot water soluble B was extracted using procedure of Berger and Truog (1939) with slight modification of adding dilute electrolyte (0.01M $CaCl_2$) instead of water for boron extraction.

Table 3.7: Critical limit of different available micronutrients:

Micronutrient	Critical Limit	Methods applied
B	0.55 mg kg^{-1}	Hot water &determined by colori-metrically (Gupta,1967)
Zn	0.50 mg kg^{-1}	Takkar and Mann, 1975
Cu	0.20 mg kg^{-1}	Lindsay and Norvell ,1978
Mn	2.0 mg kg^{-1}	Lindsay and Norvell ,1978
Fe	4.5 mg kg^{-1}	Lindsay and Norvell ,1978

Table 3.8: **Limits of different nutrients classification and their methods:**

Constituents	Method	Limits for different categories		
		Low	**Medium**	**High**
1.Available N. ($kgha^{-1}$)	Auto-kjeltech-II analyzer	< 250	250 – 400	> 400
2. Available P. ($kgha^{-1}$)	UV-sptronic Olsen's method (1954)	< 10	10 – 20	> 20
3. Available K. ($kgha^{-1}$)	Flame photometer (Jackson, 1973)	< 250	250 – 400	> 400
4. Available S. ($kgha^{-1}$)	Turbidimetric method (Chesnin and Yein, 1951)	< 20	20 – 40	> 40
5. Organic carbon (%)	Walkeley and Black's (1934)	< 0.5	0.5 – 0.75	> 0.75
		Normal	**Toward critical**	**Above critical**

6. pH	Soil : Water (1 : 2)	6.5 – 7.5	7.5 – 8.5	> 8.5
7. E.C. (dSm^{-1})	Soil : Water (1 : 2)	< 1.0	1.0 – 2.0	> 2.0

Available Micronutrient ($mgkg^{-1}$)	**Methods**	**deficient**	**sufficient**
8.Zn	Extracted from DPTA Extract and analysed by AAS (Lindsay and Norvell, 1978)	< 0.5	**>**0.5
9.Fe		<4.5	>4.5
10.Cu		<0.20	>0.20
11.Mn		<2.0	>2.0
12.B	Hot water &determined by calorimetrically (Gupta,1967)	<0.55	>0.55

Nutrient Index:

Nutrient index was calculated by the formula given by Biswas and Mukherjee, 1989.

$$\frac{NL + 2NM + 3NH}{NL + NM + NH}$$

Where,

NL = Number of sample in low categories.

NM = Number of samples in medium categories.

NH = Number of samples in high categories.

The nutrient index classes were categorized into low, medium and high class by comprising the calculated value of nutrient index (NI) with the recommended levels as per the following standard classes:

Low < 1.5, medium 1.5 - 2.5, High > 2.5

Chapter- IV

RESULTS

For the present study, two hundred fifty (250) soil samples (0-15 cm) were collected from the fields of four blocks (namely; Morar, Dabra, Bhitarwar and Ghatigoan) of Gwalior district. This chapter deals with the result obtained during the course of investigation to find out the "Studies on available nutrient status of Gwalior district" The result obtained from different studies are presented in the following paragraphs.

The results have, therefore, been presented under different sections.

- Physico-chemical properties and available nutrients status.
- Fertility status of sample area (Gwalior district).
- Mapping for major and micro nutrients.

4.1 Physico-chemical properties and available nutrients status:

A. Morar block:

From the Morar block 90 soil samples were collected using GPS and analyzed for physico-chemical properties and available nutrients. The status of 90 soil sample is presented in appendix 1.

Data presented in table 4.1 showed that pH varied from 7.10-8.90 (mean 7.73), EC from 0.27-0.63 dSm^{-1} (mean 0.43 dsm^{-1}), OC from 3.1-6.1g kg^{-1} (mean 4.3 g kg^{-1}).

Table 4.1: Physico-chemical properties and available nutrients status of Morar block:

Fertility variables	Range	Mean	Nutrients status (%)		
			Low	Medium	High
pH	7.1-8.9	7.73			
EC (dSm^{-1})	0.27-0.63	0.43			
OC (g kg^{-1})	3.10-6.10	4.30	82.22	16.66	1.11
N (kg ha^{-1})	100.30-236.06	177.47	100.00	0.00	0.00
P (kg ha^{-1})	8.25-45.10	22.88	6.66	42.22	51.11
K (kg ha^{-1})	120.90-708.90	337.87	32.22	37.77	30
S (kg ha^{-1})	9.04-68.02	26.92	32.22	52.22	15.55

Fertility variables	Range	Mean	Deficient%	Sufficient%
Zn (mg kg^{-1})	0.20-8.40	0.88	38.88	61.11
Cu (mg kg^{-1})	0.11-2.00	1.56	5.55	94.44
Fe (mg kg^{-1})	1.41-29.79	8.85	17.77	82.22
Mn (mg kg^{-1})	2.71-10.10	6.89	0.00	100.00
B (mg kg^{-1})	1.16-5.86	3.15	0.00	100.00

The available N content varied from 100.3-236.06 $kgha^{-1}$ with the mean value of 177.47 kg ha^{-1}. All the soil samples (100 %) were found in low and none of the soil sample was found in medium and high category. The available P content varied from 8.25-45.1 kg ha^{-1} with the mean value of 22.88 kg ha^{-1}. About 6.66 % soil sample were found in low, 42.22 % medium and 51.11% soil samples were found in high category. The available K content varied from 120.9-708.9 kg ha^{-1} with the mean value of 337.87$kgha^{-1}$. About 32.22 % soil sample were found in low, 37.77 % in medium and 30% soil samples were found in high category. The available S content varied from 9.04-68.02 $kgha^{-1}$ with the mean value was found 26.92$kgha^{-1}$. About 32.22 % soil sample were found in low, 52.22 % in medium and 15.55% in high category. The available Zn content varied from 0.20-8.40 mg kg^{-1} with the

Mean value of 0.88 mg kg^{-1}. About 38.8 % soil sample were found in deficient and 61.11% soil samples were found in sufficient category. The available Cu content varied from 0.11-2.0 mg kg^{-1} with the mean value of 1.56 mg kg^{-1}. About 5.55% soil samples were found deficient and 94.44% sufficient. The available Fe content varied from 1.41-29.79 mg kg^{-1} with the mean value 8.85 mg kg^{-1}. About 17.77 % soil sample were found in deficient and 82.22 % sufficient. The available Mn content varied from 2.71-10.10 mg kg^{-1} with the mean value 6.89 mg kg^{-1} and 100 % soil samples were found in sufficient category and non of the in deficient category. The available B content varied from 1.16-5.86 mg kg^{-1} with the mean value 3.15 mg kg^{-1} and 100 % soil samples were found in sufficient category and none of the in deficient category.

B. Dabra block:

From the Dabra block 30 soil samples were collected using GPS and analyzed for physico-chemical properties and available nutrients. The status of 30 soil samples is presented in appendix 1.

Table 4.2: Physico-chemical properties and available nutrients status of Dabra block:

Fertility variables	Range	Mean	Nutrients status		
			L%	M%	H%
pH	7.1- 8.5	7.83			
EC (dSm^{-1})	0.29-0.63	0.47			
OC($g\ kg^{-1}$)	4.00-7.80	5.20	40.00	53.33	6.66
N ($kg\ ha^{-1}$)	112.80 -213.20	168.46	100.00	0.00	0.00
P ($kg\ ha^{-1}$)	9.37-22.90	15.53	6.66	73.33	20.00
K ($kg\ ha^{-1}$)	127.50-688.80	314.24	36.66	43.33	20.00
S ($kg\ ha^{-1}$)	4.25-55.71	20.53	60.00	23.33	16.66
Fertility variables	**Range**	**Mean**	**Deficient%**	**Sufficient%**	
Zn ($mg\ kg^{-1}$)	0.33-4.20	1.47	13.33	86.66	
Cu ($mg\ kg^{-1}$)	0.99-4.04	2.34	0.00	100.00	
Fe ($mg\ kg^{-1}$)	6.40-29.70	14.32	0.00	100.00	
Mn ($mg\ kg^{-1}$)	2.60-8.10	4.67	0.00	100.00	
B ($mg\ kg^{-1}$)	1.9-6.29	4.46	0.00	100.00	

The data presented in table 4.2 indicated that the pH varied between7.18.5 (mean7.83), EC from 0.29-0.63 dSm^{-1} (mean 0.47 dSm^{-1}), OC in between 4.0-7.8 g kg^{-1} (mean 5.2 g kg^{-1}). About 40% soil sample were found in low, 53.33% in medium and 6.66% in high category.

The available N content varied from 112.8 -213.2 $kgha^{-1}$ with the mean value of 168.46 $kgha^{-1}$. About 100 % soil sample were found in low, none of the soil sample was found in medium and high category. The available P content varied from 9.37-22.9 $kgha^{-1}$ with the mean value of 15.53 kg ha^{-1}. About 6.66% soil sample were found in low, 73.33% medium and 20.00% in high category. The available K content varied between 127.5 to 688.8 kg ha^{-1} with the mean value of 314.24 kg ha^{-1}. About

36.66 % soil sample were found in low, 43.33 % in medium and 20% in high category. The available S Content varied 4.25-55.71 kg ha^{-1} with the mean value of 20.53 kg ha^{-1}. About 60 % soil sample were found in low, 23.33 % in medium and 16.66% in high category. The available Zn content varied from 0.33 to 4.20 mg kg^{-1} with the mean value of 1.47 mg kg^{-1}. About 13.33% soil sample were found in deficient and 86.66% in sufficient category. The available Cu content varied from 0.99-4.09 $mgkg^{-1}$ with the mean value of 2.34 mg kg^{-1}. None of the sample was found in deficient category and 100% in sufficient category. The available Fe content varied from 6.4-29.7 $mgkg^{-1}$ with the mean value of 14.32 mg kg^{-}1.None of the sample was found in deficient category and 100% in sufficient category. The available Mn content varied from 2.6-8.1 mg kg^{-1} with the mean value 4.65 mg kg^{-1}. None of the sample was found in deficient category and 100% in sufficient category. The available B content varied from 1.9-6.29 mg kg^{-1} with the mean value 3.15 mg kg^{-1}. None of the sample was found in deficient category and 100% in sufficient category.

C Bhitarwar block:

From the Bhitarwar block 80 soil samples were collected using GPSand analyzed for physico-chemical properties and available nutrients.The status of 80 soil samples is presented in appendix 1.

The data presented in table 4.3 showed that the pH varied from 6.5-8.3 (mean 7.72), EC from 0.18-0.75 dSm^{-1} (mean 0.49 dSm^{-1}), OC from 3.2-21.4 g kg^{-1} (mean 4.7g kg^{-1}).About 81.25%soil sample were found in low, 17.5% medium and 1.25% in high category.

Table 4.3 Physico-chemical properties and available nutrients status of Bhitarwar block:

Fertility variables	Range	Mean	Nutrients status		
			L%	M%	H%
PH	6.5-8.3	7.72			
EC (dSm^{-1})	0.18-0.75	0.49			
OC (g $kg^{-1)}$	3.2-21.40	4.70	81.25	17.50	1.25
N (kg ha^{-1})	75.20-308.70	201.07	71.25	28.75	0.00
P (kg ha^{-1})	8.3-58.75	31.04	3.75	26.25	70.00
K (kg ha^{-1})	162.40-442.40	245.41	60.00	35.00	5.00

S (kg ha^{-1})	3.15-64.68	21.40	66.25	21.25	12.50
Fertility variables	**Range**	**Mean**	**Deficient %**	**Sufficient%**	
Zn (mg kg^{-1})	0.22-3.13	0.86	41.25	58.75	
Cu (mg kg^{-1})	0.11-3.80	0.98	16.25	83.75	
Fe (mg kg^{-1})	2.37-36.78	10.66	1.25	98.75	
Mn (mg kg^{-1})	2.91-23.97	8.58	0.00	100.00	
B (mg kg^{-1})	1.01-6.29	2.92	0.00	100.00	

The available N content varied from75.2 to 308.7 kg ha^{-1} with the mean value of 201.07 kg ha^{-1}. About 71.25 % soil sample were found in low, 28.75% medium and none of the sample was found in high category. The available P content varied from 8.3-58.75 kg ha^{-1} with the mean value of 31.04 kg ha^{-1}. About 3.75 % soil sample were found in low, 26.25% medium and 70% in high category. The available K content varied between162.4 to 442.4 kg ha^{-1} with the mean value 245.41kg ha^{-1}. About 60 % soil sample were found in low, 35 % in medium and 5% in high category. The available S content varied from 3.15 to 64.68 kg ha^{-1} with the mean value of 21.40 kg ha^{-1}. About 66.25 % soil sample were found in low, 21.25 % in medium and 12.5% in high category.

The available Zn content varied from 0.22-3.13 mg kg^{-1} with the mean value of 0.86 mg kg^{-1}. About 41.25% soil sample were found in deficient and 58.75% in sufficient category. The available Cu content varied from 0.11-3.8 mg kg^{-1} with the mean value0.98 mg kg^{-1}. About 16.25% soil samples were found in deficient and 83.75 % in sufficient category. The available Fe content varied from 2.37-36.78 mg kg^{-1} with the mean value of 10.66 mg kg^{-1} .About 1.25 % soil sample were found in deficient and 98.75 % in sufficient category. The available Mn content varied from 2.91-23.97 mg kg^{-1} with the mean value of 8.58 mg kg^{-1}.None of soil sample was found in deficient and 100% in sufficient category. The available B content varied from 1.01-6.29 mg kg^{-1} with the mean value of 2.92. None of soil sample was found in deficient and 100% soil sample in sufficient category.

D: Ghatigaon:

From Ghatigaon block 50 soil samples were collected using GPS and analyzed for physico-chemical properties and available nutrients. The status of 50 soil samples is presented in appendix 1.

The data presented in table 4.4 showed that the pH varied from 7.0-8.3 (mean 7.71), EC from 0.26-0.86 dSm^{-1} (mean 0.49 dSm^{-1}), OC from 2.7 to 7.6 g kg^{-1} (mean 4.8 g kg^{-1}).About 64% soil sample were found in low , 34% in medium and 2% in high category.

Table 4.4 physico-chemical properties and available nutrients status of Ghatigaon block:

Fertility variables	Range	Mean	Nutrients status		
			L%	**M%**	**H%**
pH	7.0-8.3	7.71			
EC (dSm^{-1})	0.26-0.86	0.49			
OC (g kg^{-1})	2.7-7.6	4.8	64.00	34.00	2.00
N (kg ha^{-1})	87.8-319.1	182.16	84.00	16.00	0.00
P (kg ha^{-1})	6.03- 47.15	24.85	54.00	24.00	22.00
K (kg ha^{-1})	151.2- 632.8	290.24	40.00	50.00	10.00
S (kg ha^{-1})	3.97- 44.97	21.92	48.00	46.00	6.00
Fertility variables	**Range**	**Mean**	**Deficient%**	**Sufficient%**	
Zn (mg kg^{-1})	0.23-3.80	0.8	32.0	68.00	
Cu (mg kg^{-1})	0.21-4.25	1.58	0.00	100.00	
Fe (mg kg^{-1})	4.10-30.10	10.14	4.00	96.00	
Mn (mg kg^{-1})	2.80-10.70	6.87	0.00	100.00	
B (mg kg^{-1})	0.87-6.22	2.92	0.00	100.00	

The available N content varied from 87.8-319.1 kg ha^{-1} with the mean value of 182.16 kg ha^{-1}. About 84 % soil sample were found in low, 16% medium and none of the sample was found in high category. The available P content varied from 6.03-47.15 kg ha^{-1} with the mean value 24.85 kg ha^{-1}. About 54% soil sample were found in low, 24% medium and 22% in high category. The available K content varied 151.2-632.8 kg ha^{-1} with the mean value of 290.24 kg ha^{-1}. About 40 % soil sample were found in low, 50 % in medium and 10% in high category. The available S content varied from 3.97-44.97 kg ha^{-1} with the mean value of 21.92 kg ha^{-1}. About 48 % soil sample were found in low, 46 % in medium and 6% in high category.

The available Zn content varied from 0.23-3.80 mg kg^{-1} with the mean value of 0.8. About 32% soil sample were found in deficient and 68% in sufficient

Category. The available Cu content varied from 0.21-4.25 mg kg^{-1} with the mean value 1.58 mg kg^{-1}. None of the soil sample was found in deficient and 100 % in sufficient category. The available Fe content varied from 4.1-30.1 mg kg^{-1} with the mean value of 10.14 mg kg^{-1}. About 4% soil sample were found in deficient and 96% in sufficient category. The available Mn content varied from 2.8-10.7 mg kg^{-1} with the mean value 6.87 mg kg^{-1}. None of the soil sample was found in deficient and 100% in sufficient category. The available B content varied from 0.87-6.22 mg kg^{-1} with the mean value 2.92 mg kg^{-1}. None of the soil sample was found in deficient and 100% in sufficient category.

4.5 Physico-chemical properties and available nutrients status of Gwalior district (As a whole):

Descriptive statistics of soil properties:

The soil pH varied from 6.5-8.9 (mean 7.73), EC 0.18-0.86 dSm^{-1} (mean 0.46 dSm^{-1}), From Gwalior district, 250 surface soil samples were collected using GPS and analyzed for physico-chemical soil properties, available N, P, K, S, Zn, Cu, Fe, Mn and B in this district (Appendix 1). The data presented in Table-4.5 indicate that OC 2.7-21.4g kg^{-1} (mean 4.6 g kg^{-1}) respectively. The available N, P, and K varied from 75.2-319.1 kg ha^{-1}, 6.03-58.75 kg ha^{-1} and 120.9-708.9 kg ha^{-1} with mean value of 184.88 kg ha^{-1}.

Table 4.5 Physico-chemical properties & available nutrients status of Gwalior district.

Fertility variables	Range	Mean	Nutrients status		
			L%	M%	H%
pH	6.5-8.9	7.73			
EC (dSm^{-1})	0.18-0.86	0.46			
OC (g kg^{-1})	2.70-21.40	4.6	73.20	24.80	2.00
N (kg ha^{-1})	75.20-319.10	184.88	87.60	12.40	0.00
P (kg ha^{-1})	6.03-58.75	25.0	15.20	37.20	47.60
K (kg ha^{-1})	120.90-708.90	295.92	43.20	40.00	16.80
S (kg ha^{-1})	3.15-68.02	23.39	49.60	37.60	12.80
Fertility variables	**Range**	**Mean**	**Deficient%**	**Sufficient%**	
Zn (mg kg^{-1})	0.20-8.40	0.93	35.20	64.80	
Cu (mg kg^{-1})	0.11-4.25	1.47	7.20	92.80	
Fe (mg kg^{-1})	1.41-36.78	10.34	7.60	92.40	
Mn (mg kg^{-1})	2.60-23.97	7.16	0.00	100.00	
B (mg kg^{-1})	0.87-6.29	3.19	0.00	100.00	

25.0 kg ha^{-1} and 295.92 kg ha^{-1}, respectively, The S varied from 3.15-68.02 $kgha^{-1}$ with a mean value of 23.39 kg ha^{-1}. The available micronutrients Zn, Cu, Fe Mn and B varied from 0.2-8.4, 0.11-4.25, 1.41-36.78, 2.6-23.97 and 0.87-6.29 mg kg^{-1} with mean values of 0.93 , 1.47, 10.34, 7.16 and 3.19 mg kg^{-1} ,respectively in the district as a whole.

The overall available N, P, K and S deficiency of soil samples in Gwalior district was observed as 87.60%, 15.20%, 43.20% and 49.60%, respectively. Amongst the micronutrients the overall deficiency of Zn, Cu and Fe in Gwalior district was observed as 35.20%, 7.20% and 7.6% respectively. None of soil sample was found deficient in available Mn and B in Gwalior district.

4.6 Nutrient Index:

Nutrient index of different blocks was calculated by the formula given by Biswas and Mukherjee, (1989) and presented in Table 4.6

The concept of soil nutrient index was evaluated for the soils of Gwalior district of Madhya Pradesh and found in category of low fertility status for nitrogen and OC and medium with respect to phosphorus, potassium and sulphur. The value worked out from nutrient index for NPKS, OC were 1.12, 2.32, 1.73, 1.63 and 1.28 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

Under different blocks of Gwalior district, Morar block showed higher nutrient index for KS as compared to other block. In the case of OC, Dabra block showed higher nutrient index as compared to other blocks. And in case of NP, Bhitarwar block showed higher nutrient index as compare to other blocks.

Table 4.6: Nutrient Index under different blocks of Gwalior district:

Nutrients	Blocks				District as a whole
	Morar	Dabra	Bhitarwar	Ghatigoan	
N	1.00	1.00	1.28	1.16	**1.12**
P	2.44	2.00	2.66	1.68	**2.32**
K	1.97	1.83	1.45	1.70	**1.73**
S	1.83	1.56	1.46	1.58	**1.63**
OC%	1.18	1.66	1.20	1.38	**1.28**

4.7 Classification of fertility status of sample area (Gwalior district):

Table 4.7 classification of fertility status of Gwalior district (N, P& K):

S. No.	Name of block	Available -Nitrogen (No. of sample with percent)			Available -phosphorus (No. of sample with percent)			Available-potassium (No. of sample with percent)		
		L	M	H	L	M	H	L	M	H
1	**Morar (90)**	90 (100%)	0.0 (0.00%)	0.0 (0.00%)	6 (6.60%)	38 (42.20%)	46 (51.10%)	29 (32.20%)	34 (37.70%)	27 (30.00 %)
2	**Dabra (30)**	30 (100%)	0.0 (0.00%)	0.0 (0.00%)	2 (6.60%)	22 (73.30%)	6 (20.00%)	11 (36.60%)	13 (43.30%)	6 (20.00%)
3	**Bhitarwar (80)**	57 (71.20%)	23 (28.70%)	0.0 (0.00%)	3 (3.70%)	21 (26.2%)	56 (70.00%)	48 (60.00%)	28 (35.00%)	4 (5.00%)
4	**Ghatigaon (50)**	42 (84.00%)	8 (16.00%)	0.0 (0.00%)	27 (54.00%)	12 (24.00%)	11 (22.00%)	20 (40.00%)	25 (50.00%)	5 (10.00%)
5	**District As a Whole (250)**	219 (87.60%)	31 (12.40%)	0.0 (0.00%)	38 (15.20%)	93 (37.22%)	119 (47.60%)	108 (43.20%)	100 (40.00%)	42 (16.80%)

a. Available Nitrogen status:

Status of nitrogen under investigated area was presented in table 4.7. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 90 (100%), 30 (100%), 57 (71.20%) and 42 (84%) sample were found in low category and 23 (28.70%) and 8 (16%) were found in medium category respectively in and Ghatigaon. As a whole (Gwalior) 219 (87.60%) samples were found in low category and 31 (12.40%) samples were found in medium category.

b. Available Phosphorus status:

Status of phosphorus under investigated area was presented in table 4.7. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 6 (6.60%), 2 (6.60%), 3 (3.70%) and 27 (54.00%) sample were found in low category and 38 (42.20%), 22 (73.30%), 21 (26.25) and 12 (24%) were found in medium category respectively and 46 (51.1%), 6 (20%), 56 (70%) and 11 (22%) samples were found in high category. As a whole (Gwalior) 38 (15.20%) were found in low category and 93 (37.20%) found in medium category and 119 (47.60%) in high category.

c. **Available Potassium status:**

Status of potassium under investigated area was presented in table 4.7. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 29 (32.2%), 11 (36.6%), 48 (60%) and 20 (40%) sample were found in low category and 34 (37.7%), 13 (43.3%), 28 (35%) and 25 (50%) were found in medium category respectively and 27 (30 %), 6 (20%), 4 (5%) and 5 (10%) samples were found in high category. As a whole (Gwalior) 108 (43.2%) samples were found in low category and 100 (40%) found in medium category and 42 (16.8%) in high category.

Table 4.8 classification of fertility status of Gwalior district (OC, S & Zinc):

S. No.	Name of block	OC. g kg^{-1} (No. Of sample with percent)			Available -Sulphur (No. Of sample with percent)			Available- Zinc (No. of sample with percent)	
		L	M	H	L	M	H	Deficient	Sufficient
1	**Morar (90)**	74 (82.20%)	15 (16.60%)	1 (1.10%)	29 (32.20%)	47 (52.20%)	14 (15.50%)	35 (38.80%)	55 (61.10%)
2	**Dabra (30)**	12 (40%)	16 (53.30%)	2 (6.60%)	18 (60.00%)	7 (23.30%)	5 (16.60%)	4 (13.30%)	26 (86.60%)
3	**Bhitarwar (80)**	65 (81.20%)	14 (17.50%)	1 (1.20%)	53 (66.20%)	17 (21.20%)	10 (12.50%)	33 (41.20%)	47 (58.70%)
4	**Ghatigaon (50)**	32 (64%)	17 (34%)	1 (2.00%)	24 (48.00%)	23 (46.00%)	3 (6.00%)	16 (32.00%)	34 (68.00%)
5	**District As a Whole (250)**	183 (73.20%)	62 (24.80%)	5 (2.00%)	124 (49.60%)	94 (37.60%)	32 (12.80%)	88 (35.20%)	162 (64.80%)

Table 4.9 Classification of fertility status of Gwalior district (Cu and Mn):

S. No.	Name of block	Available - copper (No. Of sample with percent)		Available-manganese (No. Of sample with percent)	
		Deficient	Sufficient	Deficient	Sufficient
1	**Morar (90)**	5 (5.50%)	85 (94.40%)	0.0 (0.00%)	90 (100%)
2	**Dabra (30)**	0.0 (0.00%)	30 (100%)	0.0 (0.00%)	30 (100%)
3	**Bhitarwar (80)**	13 (16.20%)	67 (83.70%)	0.0 (0.00%)	80 (100%)
4	**Ghatigaon (50)**	0.0 (0.00%)	50 (100%)	0.0 (0.00%)	50 (100%)
5	**District As a Whole (250)**	18 (7.20%)	232 (92.80%)	0.0 (0.00%)	250 (100%)

d. Organic Carbon status(%):

Status of OC. in soil under investigated area was presented in table 4.8. 90, 30,80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively . In which 74 (82.20%), 12 (40%), 65 (81.20%) and 32 (64%) sample were found in low category and 15 (16.6%),16 (53.30%),14 (17.50%) and 17 (34%) were found in medium category respectively and 1 (1.1%), 2 (6.6%), 1 (1.20%) and 1 (2%) samples were found in high category. As a whole (Gwalior) 183 (73.2%) samples were found in low category and 62 (24.80%) found in medium category and 5 (2%) in high category.

e. Available Sulphur status:

Status of sulphur under investigated area was presented in table 4.8. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 29 (32.20%), 18 (60%), 53 (66.20%) and 24 (48%) sample were found in low category and 47 (52.20%), 7 (23.30%), 17 (21.20%) and 23 (46%) were found in medium category respectively and 14 (15.50%), 5 (16.60%), 10 (12.50%) and 3 (6.00%) samples were found in high category. As a whole (Gwalior) 124 (49.60%) samples were found in low category and 94 (37.60%) found in medium category and 32 (12.80%) in high category.

f. Available Zinc status:

Status of Zinc in soil under investigated area was presented in table 4.8, 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 35 (38.80%), 4 (13.3%), 33 (41.20%) and 16 (32%) soil samples were found in deficient category respectively from each block and 55 (61.10%), 26 (86.60%), 47 (58.70%) and 34 (68%) soil samples were found in sufficient category. As a whole (Gwalior) 88 (35.20%) samples were found in deficient category and 162 (64.80%) samples found in sufficient category.

g. Available Copper status:

Status of copper under investigated area was presented in table 4.9. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 5 (5.50%), 0.0 (0.00%), 13 (16.20%) and 0.0 (0.00%) soil samples were found in deficient category respectively from each block and 85 (94.40%), 30 (100%), 67 (83.70%) and 50 (100%) soil samples were found in sufficient category. As a whole (Gwalior) 18 (7.20%) samples were found in deficient category and 232 (92.80%) samples found in sufficient category.

h. Available Manganese status:

Status of manganese under investigated area was presented in table 4.9. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 0.00 (0.00%) soil samples were found in deficient category respectively from each block and 100% soil samples were found in sufficient category in all blocks. As a whole (Gwalior) 0.00 (0.00%) samples were found in deficient category and 250 (100%) samples found in sufficient category.

i. Available Iron status:

Status of Iron under investigated area was presented in table 4.10. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 16.00 (17.70%), 0.00 (0.00%), 1.00 (1.20%) and 2.00 (4.00%) soil samples were found in deficient category respectively from each block and 74.00 (82.20%), 30.00 (100%), 79.00 (98.70%) and 48.00 (96.00%) soil samples were found in sufficient category in all blocks. As a whole (Gwalior) 19.00 (7.60%) samples were found in deficient category and 231 (92.40%) samples found in sufficient category.

Table 4.10 Classification of fertility status of Gwalior district (Fe & B):

S. No.	Block	Available- Iron (No. Of sample with percent)		Available - Boron (No. Of sample with percent)	
		Deficient	Sufficient	Deficient	Sufficient
1	Morar (90)	16.00 (17.70%)	74.00 (82.20%)	00 (0.00%)	90.00 (100%)
2	Dabra (30)	0.00 (0.00%)	30.00 (100%)	00 (0.00%)	30.00 (100%)
3	Bhitarwar (80)	1.00 (1.20%)	79.00 (98.70%)	00 (0.00%)	80.00 (100%)
4	Ghatigaon (50)	2.00 (4.00%)	48.00 (96.00%)	00 (0.00%)	50.00 (100%)
5	District as a whole (250)	19.00 (7.60%)	231.00 (92.40%)	00 (0.00%)	250 (100%)

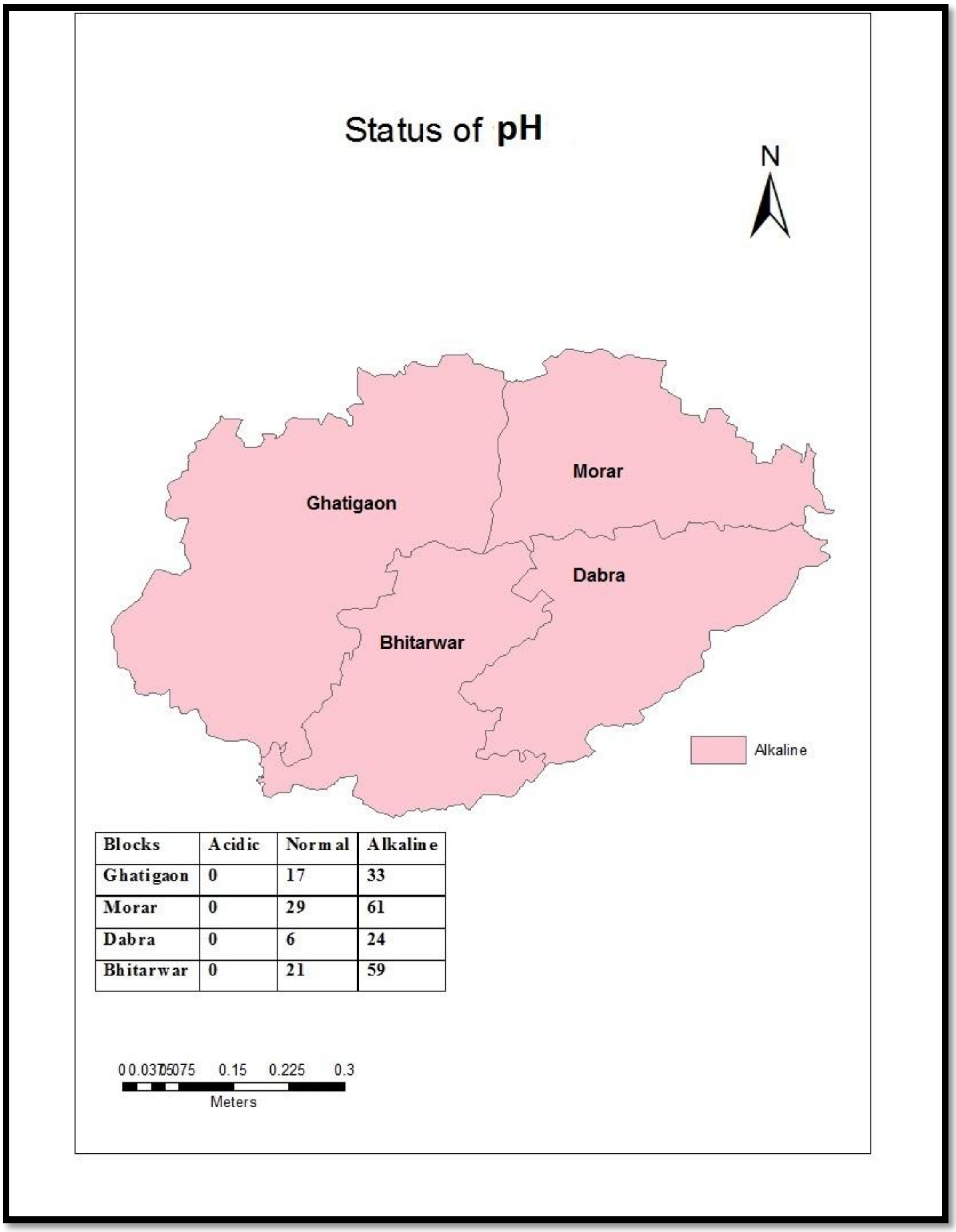
j. Available Boron status:

Status of Boron under investigated area was presented in table 4.10. 90, 30, 80 and 50 soil samples were collected from Morar, Dabra, Bhitarwar, and Ghatigaon blocks respectively. In which 0.00 (0.00%) soil samples were found in deficient category respectively from each block and 100% soil samples were found in sufficient category in all blocks. As a whole (Gwalior) 0.00 (0.00%) samples were found in deficient category and 250 (100%) samples found in sufficient category.

4.8 Soil fertility map preparation with respect to major and micro nutrients:

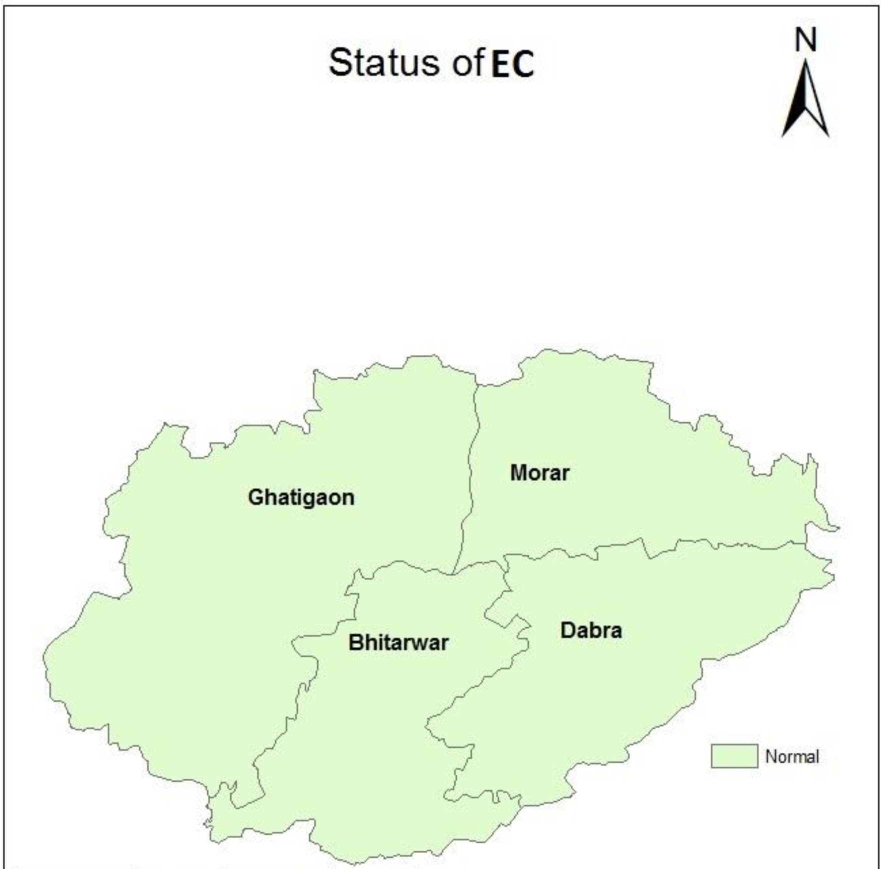
Soil fertility map were generated on the basis of general average values for Gwalior district in respect of all the major and micro nutrients by using Arc-Gis software.

4.10.1 Soil Fertility map of Gwalior district for pH:



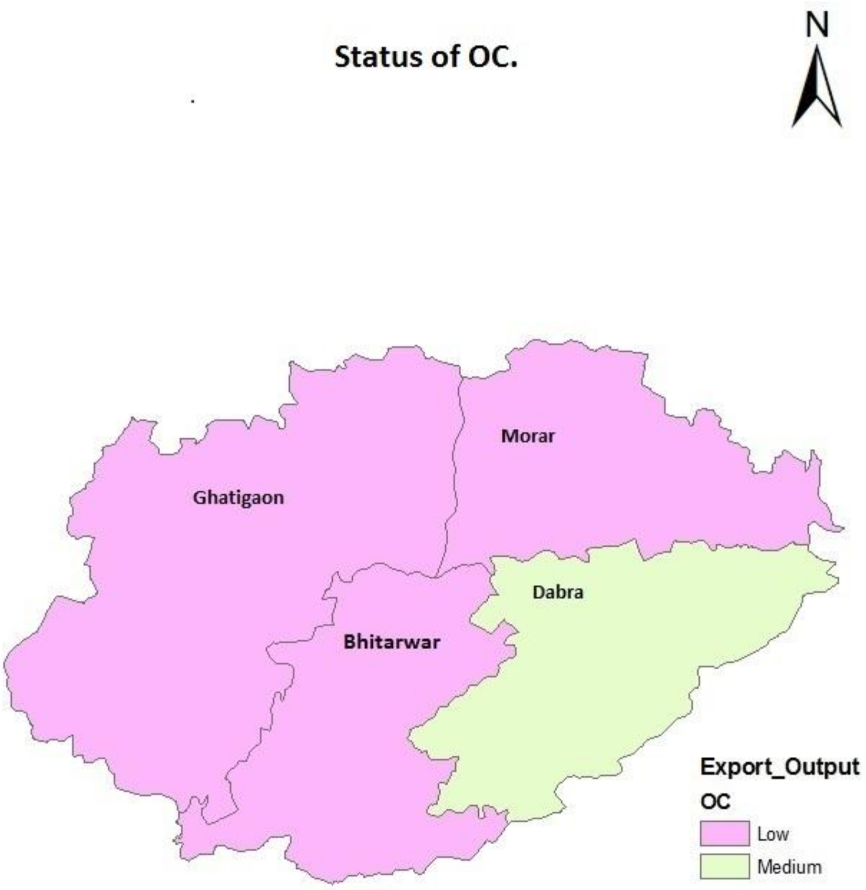
Blocks	Acidic	Normal	Alkaline
Ghatigaon	0	17	33
Morar	0	29	61
Dabra	0	6	24
Bhitarwar	0	21	59

4.10.2 Map of Gwalior district for EC values:



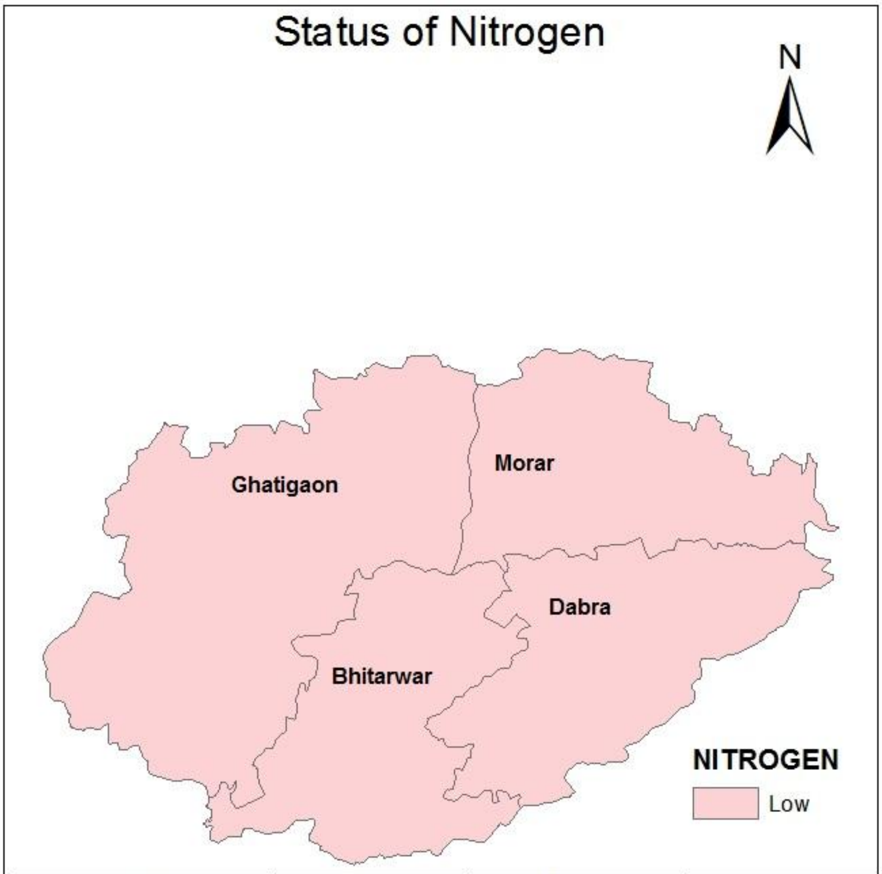
Blocks	Normal	Marginal	Critical
Ghatigaon	50	0	0
Morar	90	0	0
Dabra	30	0	0
Bhitarwar	80	0	0

4.10.3 Map of Gwalior district for OC:

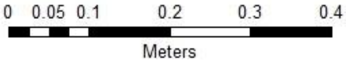


Blocks	Low	Medium	High
Ghatigaon	32	17	1
Morar	74	15	1
Dabra	12	16	2
Bhitarwar	65	14	1

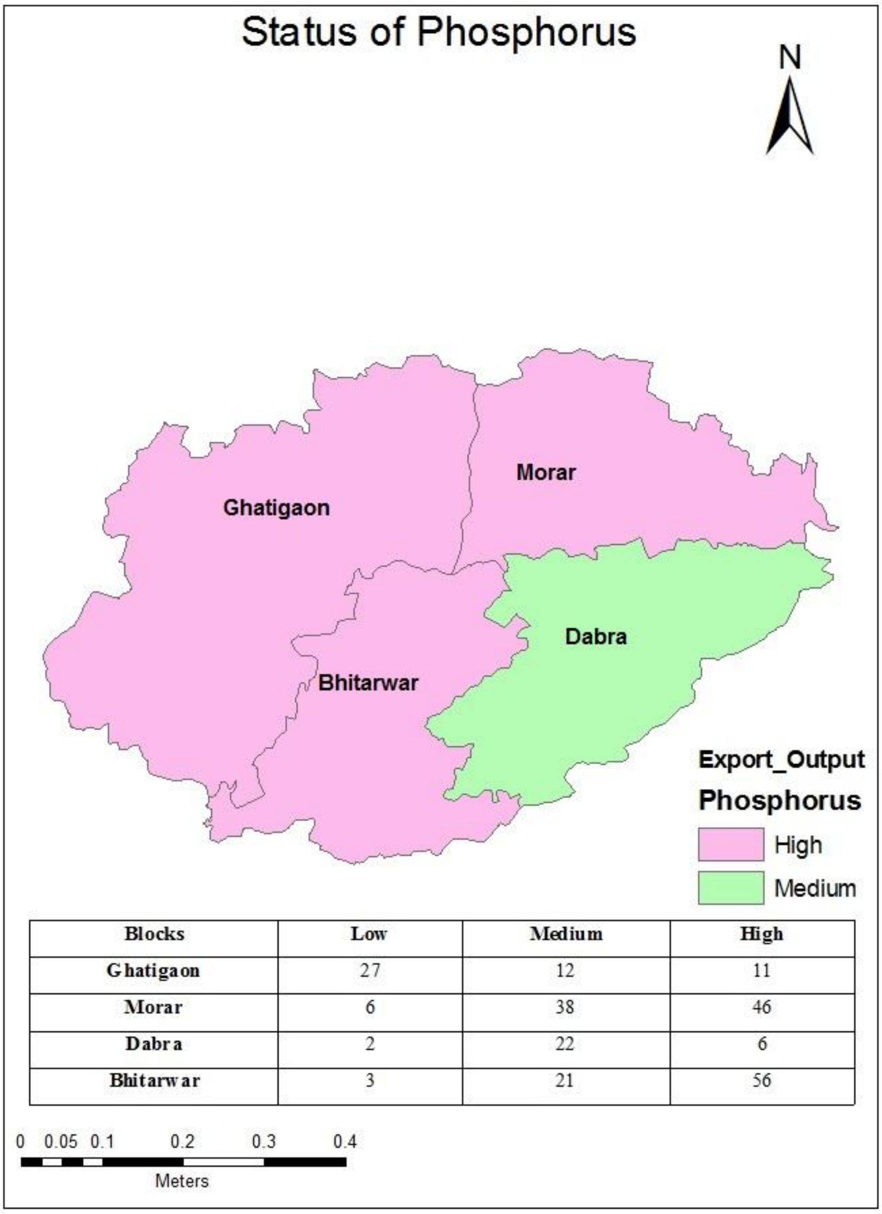
4.10.4 Map of Gwalior district for Nitrogen:



Blocks	Low	Medium	High
Ghatigaon	42	8	0
Morar	90	0	0
Dabra	30	0	0
Bhitarwar	57	23	0

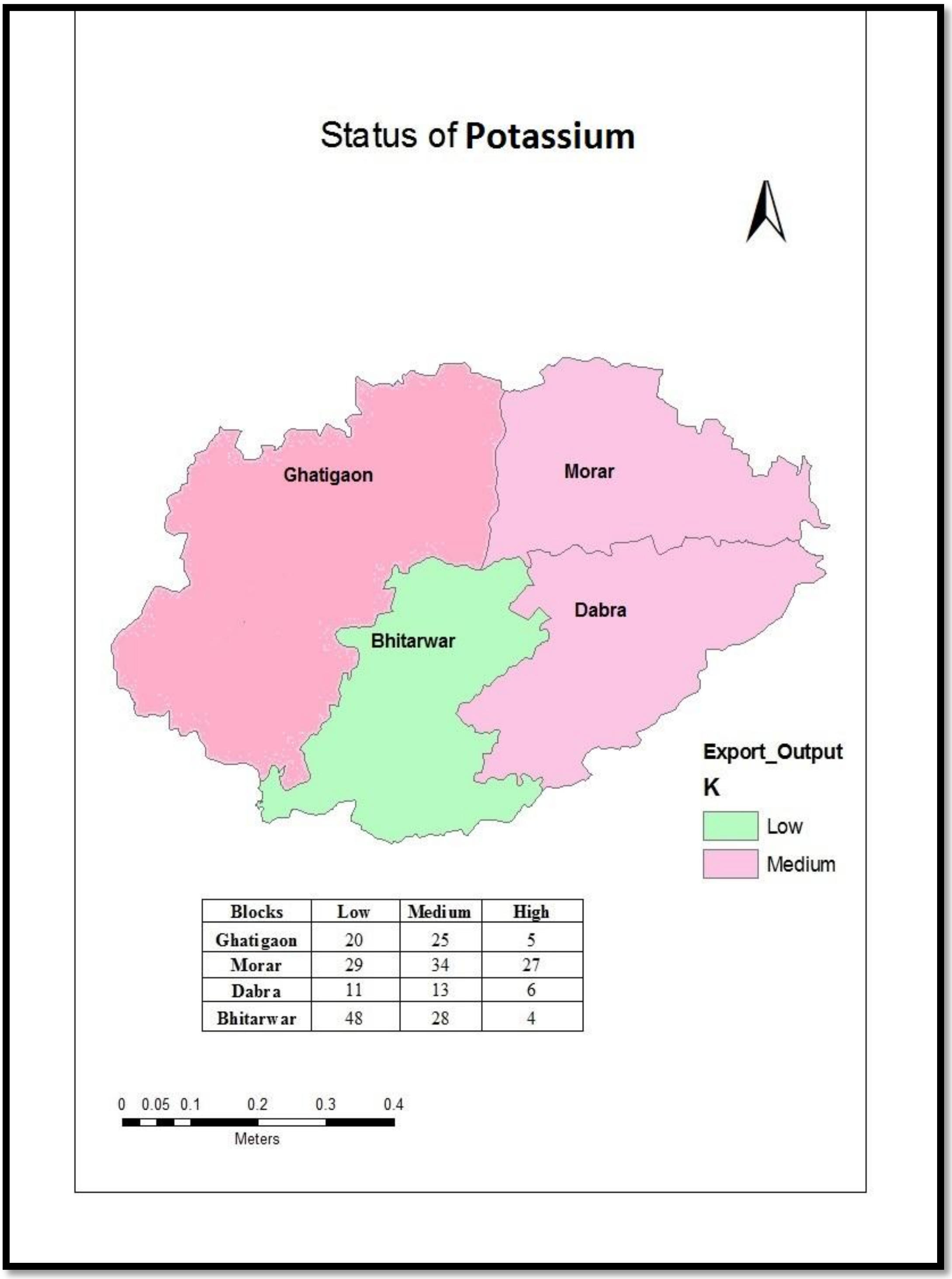


4.10.5 Map of Gwalior district for Phosphorus:



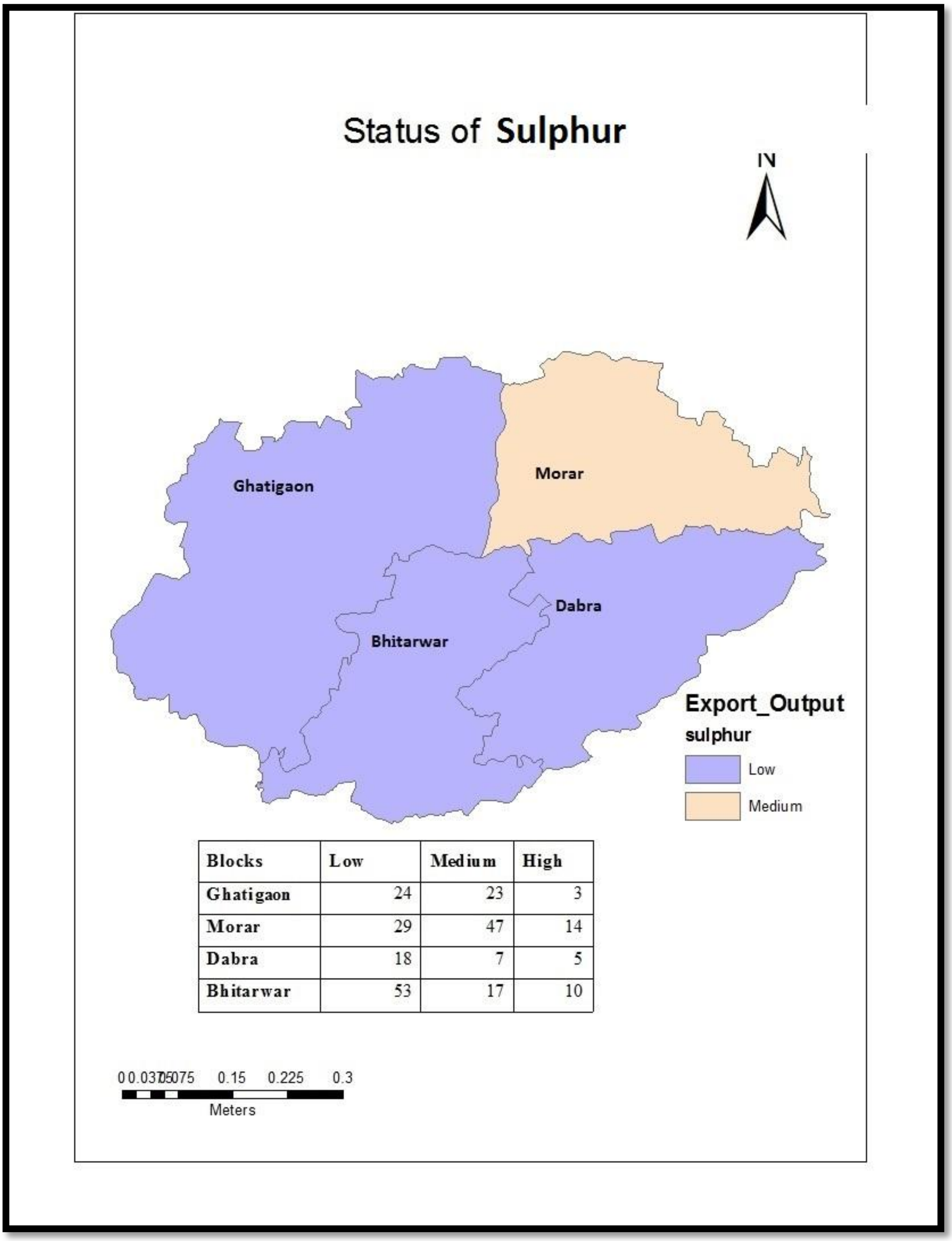
Blocks	Low	Medium	High
Ghatigaon	27	12	11
Morar	6	38	46
Dabra	2	22	6
Bhitarwar	3	21	56

4.10.6 Map of Gwalior district for Potassium:



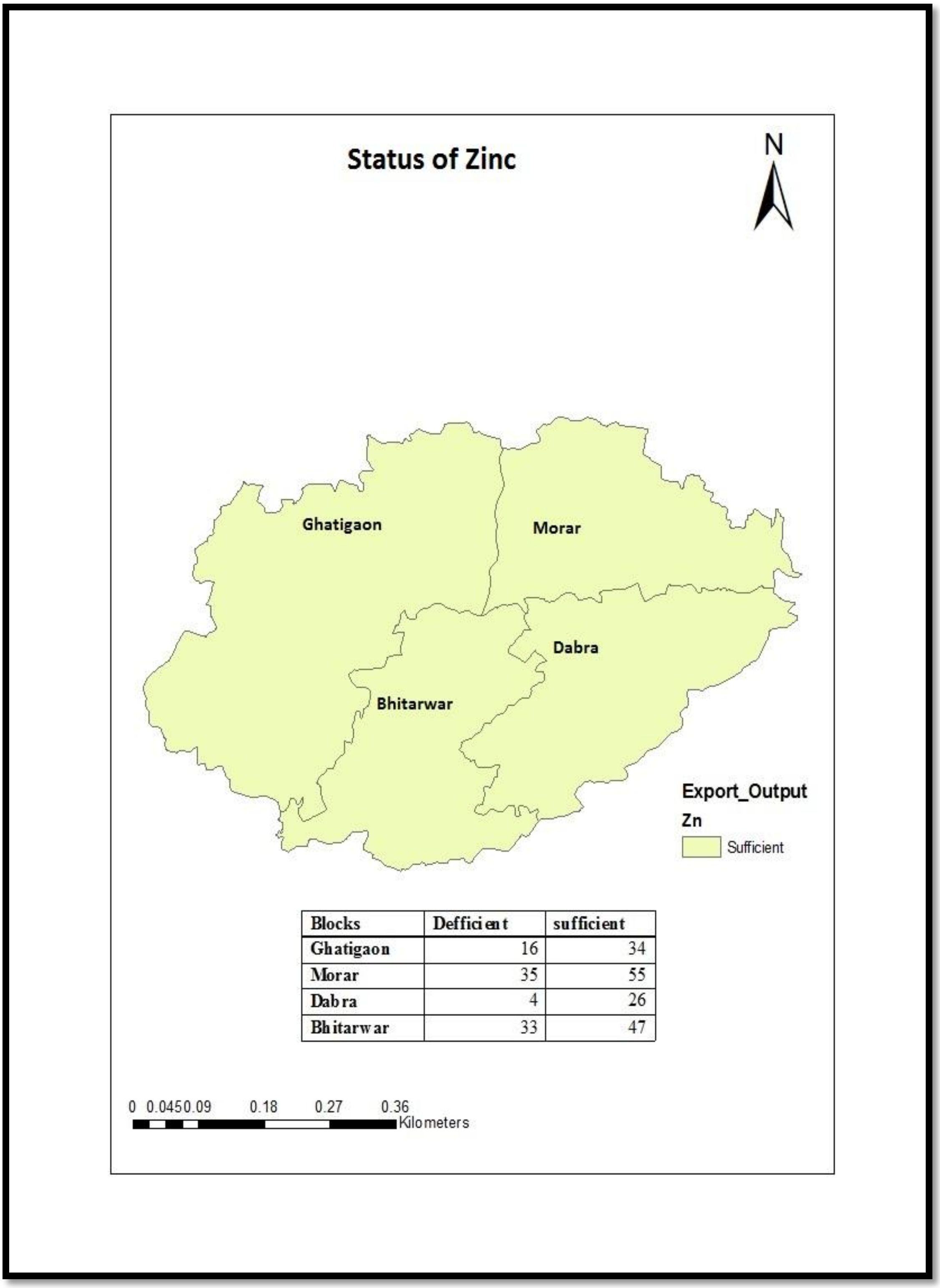
Blocks	Low	Medium	High
Ghatigaon	20	25	5
Morar	29	34	27
Dabra	11	13	6
Bhitarwar	48	28	4

4.10.7 Map preparation of Gwalior district due to Sulphur :



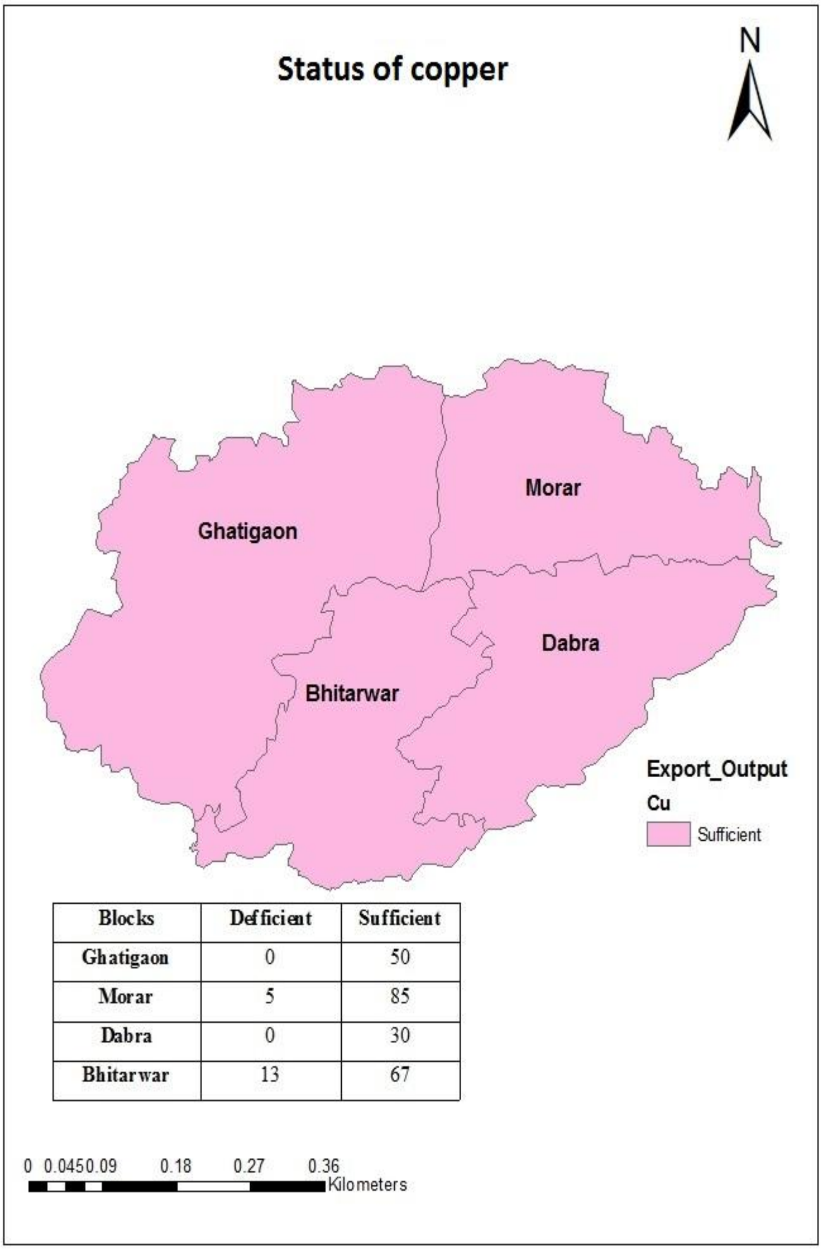
Blocks	Low	Medium	High
Ghatigaon	24	23	3
Morar	29	47	14
Dabra	18	7	5
Bhitarwar	53	17	10

4.10.8. Map of Gwalior district for Zinc content:



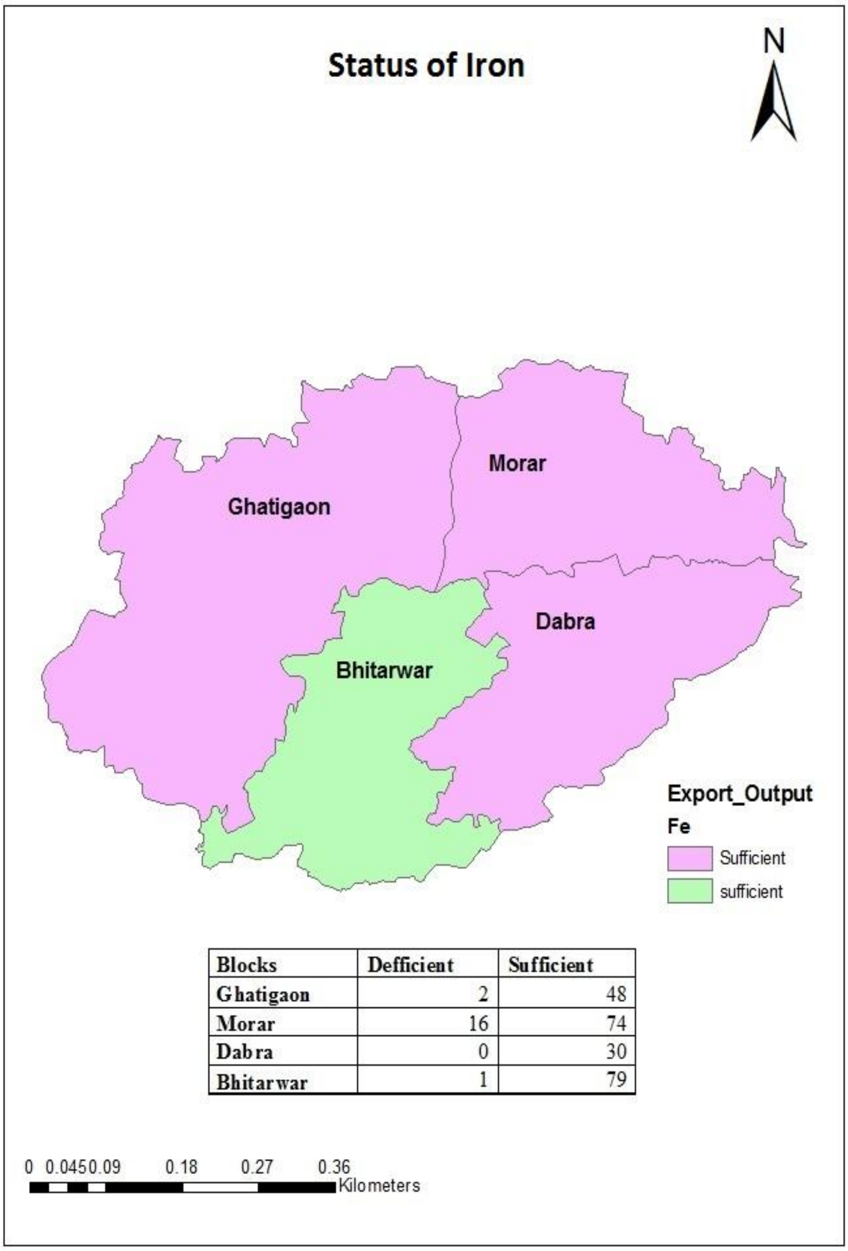
Blocks	Defficient	sufficient
Ghatigaon	16	34
Morar	35	55
Dabra	4	26
Bhitarwar	33	47

4.10.9. Map of Gwalior district for Copper contents:



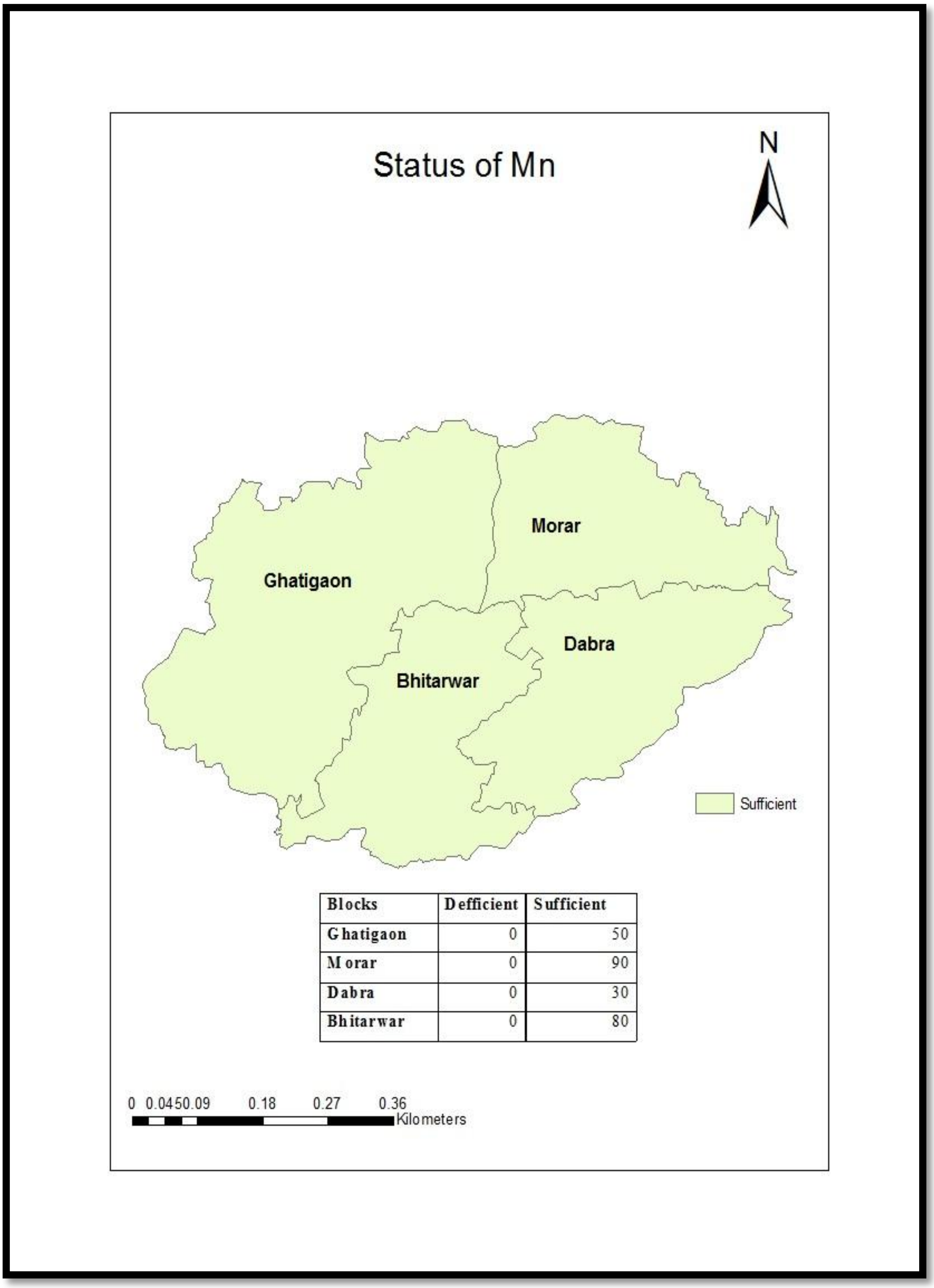
Blocks	Defficient	Sufficient
Ghatigaon	0	50
Morar	5	85
Dabra	0	30
Bhitarwar	13	67

4.11.1 Map of Gwalior district for Iron contents:



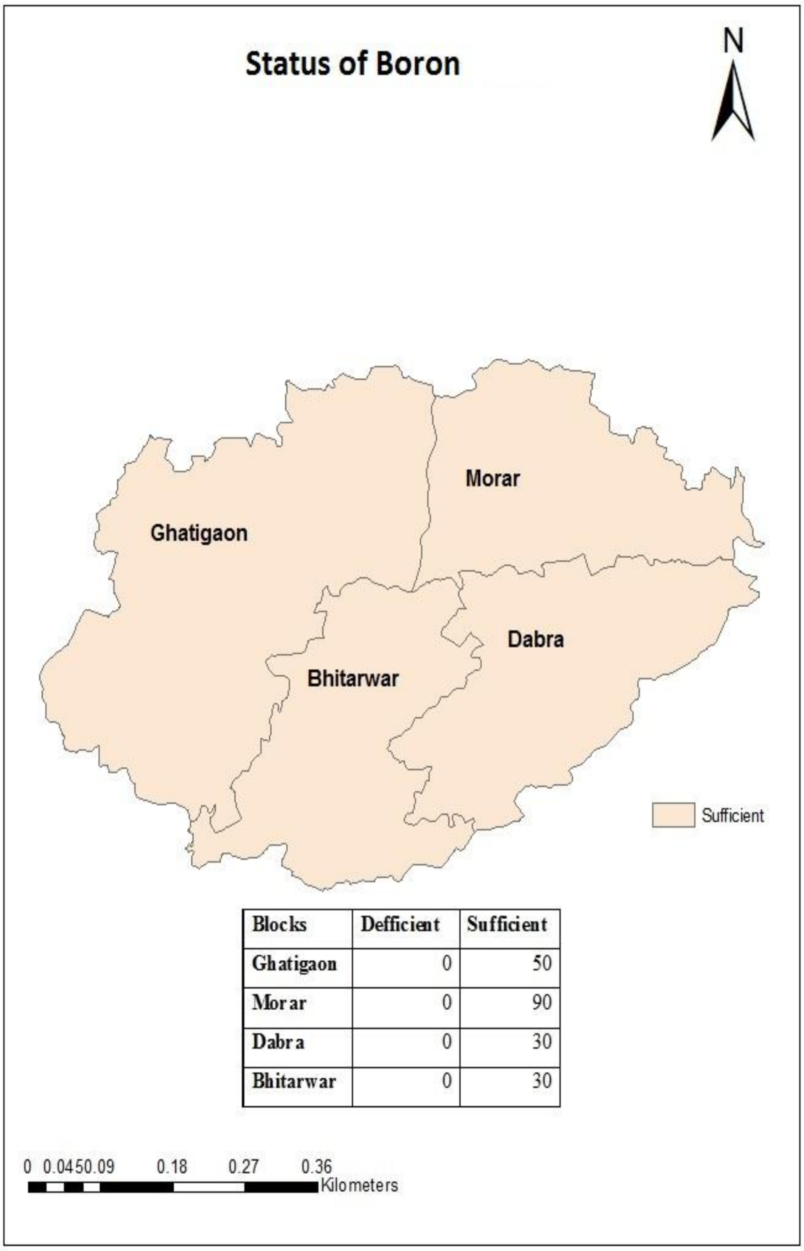
Blocks	Defficient	Sufficient
Ghatigaon	2	48
Morar	16	74
Dabra	0	30
Bhitarwar	1	79

4.11.2 Map of Gwalior district for Manganese:



Blocks	Defficient	Sufficient
Ghatigaon	0	50
Morar	0	90
Dabra	0	30
Bhitarwar	0	80

4.11.3 Map of Gwalior district for Boron:



Blocks	Defficient	Sufficient
Ghatigaon	0	50
Morar	0	90
Dabra	0	30
Bhitarwar	0	30

Chapter- V
Discussion

Two hundred fifty surface soil samples (0-15 cm) collected from four blocks (namely; Morar, Dabra, Bhitarwar and Ghatigoan) of Gwalior district. Locations of sampling sites were decided using geo- positioning system. These samples were analyzed for different physico-chemical properties, macro and micronutrients content .From each block different number of sample were collected 90,30, 80 and 50 soil samples were collected from Morar ,Dabra, Bhitarwar and Ghatigaon respectively .

Physical and chemical properties of soil:

Soil pH

Data indicates that the soils of different cropping systems of Gwalior district are slightly alkaline in reaction. Most of the soil showed pH value in the neighborhood of 7.5 $\pm$ 0.5. In some cases pH was noticed as 6.5 and 8.9 this condition seems to arise due to high degree of sodium saturation of the clay complex which on hydrolysis seems to dissociate almost completely to furnish OH^- ions which consequently increase the pH of soil water suspension. The pH appeared to be influenced by parent material, rainfall and topography (Thangaswamy *et al.* 2005). The higher pH could be due to increase in accumulation of exchangeable sodium and calcium carbonate. In general, soils from all the cropping systems were found to be normal for cultivation of different crops.

Electrical conductivity

The electrical conductivity of soil water suspension (1:2) ranged between 0.18 and 0.86 dSm^{-1} at 25^0C with mean value of 0.46 dSm^{-1}, it showed a considerable variation with type of topography of soils. On the basis of the limits suggested by Muhr *et al.* (1963) for judging salt problem of soil, all of the samples were found ($EC<1.0\ dSm^{-1}$) in the normal category of soluble salt content. The electrical conductivity of soil water suspension was low in all the samples. In general, the soils were found to have soluble salts concentration in safe limit for the satisfactory growth of different crops. Similar findings reported by Motsara (2009).

Organic carbon:

It is evident from the data on organic carbon content of the soils of different blocks may be considered low as most of the soils were found to contain less than 7.5g kg^{-1} of it. Organic carbon content varied from 2.7 to 21.4 g kg^{-1} with an average value of 4.6 g kg^{-1}. Most of the soil samples were found to be low in organic carbon content (Table 4.5). The low organic carbon content in these soils may be attributed to the poor vegetation and high rate of organic matter decomposition under hyperthermic temperature regime which leads to extremely high oxidizing conditions. Removal of the surface soil containing high organic carbon due to erosion was responsible for the lower organic carbon (Rajeswar *et al.* 2009). Besides this, course-textured soils are generally low in organic carbon (Yadav and Meena 2009).

Available N

The amount of available nitrogen in soils as determined by alkaline permanganate method ranged between 75.2 and 319.1 kg ha^{-1} with mean value of 184.88 kg ha^{-1}. On the basis of the rating suggested by Subbaiah and Asija (1956), 87.6 % samples were low (< 250 N $kgha^{-1}$) and remaining 12.4 % medium (250 to 500 N kg ha^{-1}) in available N.

According to Trivedi *et al.* (1997) organic carbon, and available N, contents of soil were greater after the harvest of black gram than mustard.

Available P

The amount of available phosphorus (0.5 M $NaHCO_3$ extractable) ranged between 6.03 kg ha^{-1} to 58.75 kg ha^{-1} with a mean value of 25.0 kg ha^{-1}. The range is quite large which might be due to variation in soil properties viz pH, calcareousness, organic matter content, texture and various management and agronomic practices. On the basis of the limits suggested by Muhr *et al.* (1963), 15.20 % samples were low (< 10 P kg ha^{-1}), 37.20% (10-20 kg ha^{-1}) samples fall under medium and 47.60% (>20,P $kgha^{-1}$) in high category . The results corroborate the findings of Motsara (2009).

Available K

Status of available potassium (kg ha^{-1}) in investigated area varied from 120.90-708.90 kg ha^{-1} with an average value of 295.92 kg ha^{-1} Under different blocks, maximum average value of available potassium (337.87 kg ha^{-1}) was recorded in Morar block followed by Bhitarwar (245.41kg ha^{-1}) with Rice -Wheat.

It is clear from results that Cereal - Cereal cropping system (Pearl millet - Wheat & Rice - Wheat) show low status of available potassium in soils as compared to other cropping system. This finding are similar to Prasad and Rokima (1991) who reported that the amount of NPK added through chemical fertilizer, organic manure and bio-fertilizer were effective in buildup of nitrogen and phosphorus but not potassium in rice- wheat cropping system.

According to Ved Prakash *et al.* (2002), in surface layer, the available K remained unchanged under 100% NK and 100% N + FYM treatments, whereas significant build up of K was noticed fewer than 100% NPK + FYM. Significant depletion of available K was observed under control, 100% NP and 100% NPK treatments.

Although most of the soils have been reported to be medium to high category in potassium but intensive cultivation of high yielding varieties of crops with application of high rates of N and P tend to deplete the K reserve of soil at a faster rate (Singh *et al.* 2000).

Available sulphur:

Status of available sulphur (kg ha^{-1}) in investigated area varied from 3.15-68.02 kg ha^{-1} an average value of 23.39 kg ha^{-1} Under different blocks, maximum average value of available sulphur (26.92 kg ha^{-1}) was recorded in Morar block and minimum (20.53 kg ha^{-1}) in Dabra block. It is clear from results that oilseed base cropping system (Fallow- Mustard & Pearl millet- Mustard) show low status of available sulphur in soils as compared to other cropping system.

With the introduction of high yielding varieties and increased cropping intensity, large amounts of nutrients are removed from the soil gradually. Oilseed crops have been reported to deplete the soil sulphur relatively to a greater extent. Mustard is widely grown in northern Madhya Pradesh. Sulphur uptake ranges from 5 to 46 kg ha^{-1} for individual crop to 78 to 80 kg ha^{-1} for intensive annual rotations. Generally, S uptake is 9 to 15% of N uptake and is comparable to P uptake. Sulphur uptake per tonne of grain production is 3 to 4 kg for cereals, 8 kg for pulses and 12 kg for oilseeds (Tandon, 1995).

viii. DTPA-extractable micronutrients:

DTPA-Zn

The DTPA-Zn in soils varied considerably and ranged from 0.2 to 8.4 mg kg^{-1} with mean value (0.9 mg kg^{-1}). The critical limit of DTPA – Zn (<0.5 mg kg $-^{1}$) as suggested by Bansal and Takkar (1986). Out of 250 samples, 35.20% samples were found to be deficient in DTPA-Zn. The samples falling under sufficient category (more than 0.5 mg $kg^{-1)}$ were 64.80%. Sharma *et al.* (2006) reported that the DTPA-Zn in soil varied from 0.18 to 3.91 mg ha^{-1} and Singh *et al.* (2006) found that DTPA-extractable Zn in the soils varied from 0.90 to 8.49 mg $kg^{-1.}$

DTPA-Fe

The content of DTPA-Fe in soils varies from 1.41 to 36.78 mg kg^{-1} with an average value of 10.34 mg kg^{-1}. Considering the deficient limits (< 4.5 mg kg^{-1}) and sufficient limit (>4.5 mg kg^{-1}) proposed by Lindsay and Norvell (1978), 7.60% samples were found deficient and 92.40% in sufficient range. Nayak (2000) reported that soils are rich in available Fe content which ranged from 7.0 to 73.6 mg ha^{-1} in the surface soils. Sharma and Chaudhary (2007) reported that the content of available Fe was higher in the surface horizons and decreased with depth in most of the soil series and ranged from 8.20 to 50.20 mg kg^{-1}.series and ranged from 8.20 to 50.20 mg kg^{-1}.

DTPA-Cu

Available copper content in soil samples varied from 0.11 to 4.25 mg kg^{-1} with mean value of 1.47 mg kg^{-1}. About 7.20% of soil samples were deficient, and 92.80% sufficient in available Cu considering critical limits (< 0.2

mg kg^{-1} low) and for deficient (>0.2 mg kg^{-1}) Katyal and Rattan (2003). Sharma *et al.* (2006) reported that the content of Cu ranged from 0.43 to 3.13 mg kg^{-1} with a highest mean value of 1.71 mg kg^{-1} in the soils of Nubra block as compared to soils of other blocks. Pawar and Totawat (2004) reported that DTPA extractable Cu ranged from 1.13 – 4.28 mg kg^{-1}. Singh *et al.* (2006) found that DTPA-extractable Cu ranged from 0.79 to 6.44 mg kg^{-1}.

DTPA-Mn

The DTPA-Mn in the soil samples varied from 2.60 to 23.97 mg kg^{-1} with an average value of 7.16 mg kg^{-1}. Considering the critical limits ((< 2 mg ha^{-1} deficient, > 2.00 $mgkg^{-1}$ sufficient) as suggested by Lindsay and Norvell (1978), 0.00% samples falls in deficient and 100% in sufficient. Meena *et al.* (2006) reported that Mn varied from and 6.85 from 45.25 mg ha^{-1} with mean value of 21.56 mg kg^{-1}. Singh and Rao (2001), Dhakad (2007) and Motsara (2009) found the similar results.

While the soil was finding sufficient for available Mn and B. It is indicated that the availability of zinc was lower than critical level. More than half of the agricultural soils were Zn deficient as reported by Rathore et al, (1980).

Boron:

Status of Boron in soil under investigated area varied from 0.87 to 6.29 mg kg^{-1} with an average value of 3.19 mg kg^{-1} all the blocks of Gwalior district was sufficient none of the sample was found in deficient category. According to critical limits (<0.55 mg kg^{-1}, deficient and >0.55 mg kg^{-1} sufficient) proposed by Gupta 1967 (Hot water & determined by calorimetrically).

Nutrient Index :

Nutrient index of different blocks was calculated by the formula given by Biswas and Mukherjee, (1989) and presented in Table 4.6.

The concept of soil nutrient index, the soils of Gwalior district of Madhya Pradesh were found in category of low fertility status for nitrogen and OC and medium with respect to phosphorus, potassium and sulphur. The value worked out from nutrient index for N P K S,OC were 1.12, 2.32, 1.73,

1.63 And 1.28 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.

Meena *et al.* (2006) also worked out from nutrient index for NPK which were 1.75, 1.70 and 2.54 respectively in soils of Tonk district of Rajasthan. According to Pattanayak *et al.* (2009) soil of Madhya Pradesh was observed in medium category with 1.84 value of nutrient index.

Soil Fertility Map generation:

The collected data on the available nutrient contents and other parameters were utilized for generating maps of Gwalior district with the help of Arc- GIS software. Different data were averaged over the blocks and the block was categorized as low, medium or high on the maximum values found in the categories. There was although similarities in maximum cases, however, in case of phosphorus, potassium, sulphur and Iron content have some different values due to adoption of different cropping pattern.

Chapter – VI

SUMMARY, CONCLUSION & SUGGESTIONS FOR FURTHER WORK

The results obtained are summarized below:

The present study was entitled as **" Soil Fertility Evaluation of Soils of Gwalior District (M.P.)"** For the study 250 surface soil samples (0-15cm) were collected from the four block namely Morar, Dabra, Bhitarwar and Ghatigaon of Gwalior district under Department of Soil Science and Agricultural Chemistry, College of Agriculture, RVSKVV, Gwalior (M.P) during the off season of 2015-16. The samples were prepared and analyzed for evaluation of micro and macro nutrients status and Classification of fertility status of sample area (Gwalior district.).

Micronutrients (Zn, Cu, Mn, Fe and B) are important soil elements which control soil fertility in combinations of macro-nutrients (NPKS). Soil characterizations in relation to available micronutrients status of the soil of an area or region are an important aspect in context of suitable agriculture production. Because of imbalanced and inadequate macro and micro fertilizers used coupled with low efficiency of other inputs has its negative impacts on crop production. The response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years. The stagnation in crop productivity cannot be boosted without individual use of micronutrients fertilizers to overcome existing deficiencies imbalances. Therefore, an attempt was made to find out the macro and micronutrients status with soil characteristics in soils of different cropping systems of Gwalior district of Madhya Pradesh.

- The soils of Morar block having the mean of soil pH 7.73, EC 0.43 dSm^{-1}, OC 4.3g kg^{-1} and The mean available N 177.47 P 22.88, K 337.87 kg ha^{-1} S 26.92 kg ha^{-1}, Zn 0.88 mg kg^{-1}, Cu 1.6 mg kg^{-1}. , Fe 8.85 mg kg^{-1}., Mn 6.89 mg kg^{-1} and B 3.15 mg kg^{-1}. The soil samples were found 100, 6.66, 32.22 and 32.22, 38.88% deficient in available N, P, K, S and Zn respectively and require the recommendation of 156, 78, 26,30 $kgha^{-1}$ and 5-6 $mgkg^{-1}$,respectively for rice/wheat crop. The corresponding recommendation of 26 N, 104 P_2O_5, 52-60 K_2O and 5-5.6 Zn kg ha^{-1} respectively for Mustard/chickpea crops.

- The soils of Dabra block having the mean value of soil pH 7.83, EC 0.47 dSm^{-1}, OC 5.2 g kg^{-1}, available N 168.21 kg ha^{-1}, P 15.53 kg ha^{-1}, K 314 kg ha^{-1} S 20.53 kg ha^{-1}, Zn 1.47 mg kg^{-1}, Cu 2.34 mg kg^{-1}, Fe 14.32 mg kg^{-1}, Mn 4.67 mg kg^{-1} and B 4.46 mg kg^{-1}. About 40, 100, 6.66, 36.66, 60 and 13.33% soils sample were found deficient in available OC, N, P, K, S and Zn respectively and the required recommendation of 156-180 N, 78-90 P_2O_5, 52 K_2O, 26-30 S kg $ha^{-1}$and 5 Zn, Mn mg kg^{-1} respectively and 10 tone FYM ha^{-1}. The corresponding recommendation of mustard/chickpea crop is 26-30 N, 104-120 P_2O_5, 26 K_2O, 52-60 S, 5 Zn mg kg^{-1}.

- The soils of Bhitarwar block having the mean value of soil pH 7.72, EC 0.49 dSm^{-1}, OC 4.7g kg^{-1} and available N 201.07, P 31.04, K 245.41 kg ha^{-1} S 21.40, Zn 0.86, Cu 0.98, Fe 10.66, Mn 8.58 and B 2.92 mg kg^{-1}. About 81.25, 71.25, 3.75, 60, 66.25, 41.25 ,16.25, 1.25% soils sample were found deficient in available OC g kg^{-1}, N, P, K, S, Zn ,Cu,and Fe respectively and required the recommendation of 156-180 N, 52 K_2O, 26-30 S, 2.5-3.25 Zn and 5 Fe $mgkg^{-1}$ respectively for rice/wheat crop. The corresponding recommendation for mustard/chickpea crop is 26-30 N, 26 K_2O, 52-60 S, 5-6.5 Zn kg ha^{-1} and 6 tones FYM ha^{-1}.

- The soils of Ghatigaon block having the mean value of soil pH 7.71, EC 0.49 dSm^{-1}, OC 4.8 g kg^{-1} , available N 182.16, P 24.85, K 290.24 kg ha^{-1} ,S 21.29 kg ha^{-1}, Zn 0.8, Cu 1.58, Fe 10.14, Mn 6.87 and B 2.92 mg kg $^{-1}$. About 64, 84, 54, 40, 48, 32, 4% soils sample were found deficient in available OC g kg^{-1}, N, P, K, S, Zn and Fe respectively and requires recommendation of 156-180 N, 78-90 P_2O_5, 52 K_2O, 26-30 S kg ha^{-1} and 2.5-3.25 Zn mg kg^{-1} respectively for rice/wheat crop. The corresponding recommendation for soybean/chickpea crop is 26-30 N, 104-120 P_2O_5, 26 K_2O, 52-60 S, and 5-6.5 Zn $kgha^{-1}$.

CONCLUSION:

- From the preceding summary it can be concluded that most of the soils samples of different blocks of Gwalior district of Madhya Pradesh are normal in reaction and soluble salts and pH is slightly towards alkaline. Surface soil samples are low to medium in organic carbon content. All soil samples of different blocks falls low in available Nitrogen, available potassium, OC g kg^{-1} and medium in available P status. DTPA-Zn, Fe and Cu were found in deficient range. However, Mn and B in sufficient range. The soils of Gwalior district of Madhya Pradesh were found in category of low fertility status for nitrogen and OC and medium with respect to phosphorus, potassium and sulphur. The value worked out from nutrient index for NPKS, OC were 1.12, 2.32, 1.73, 1.63 and 1.28 respectively, against the nutrient index values <1.50 for low, 1.50-2.50 for medium and >2.50 for high fertility status.The maps prepared in respect of soil fertility status can be utilized by administration for improving soil health and enhancing crop production.

Suggestions for future research work:

- Periodic assessment of soil nutrients is necessary to optimize crop productivity and to maintain soil health.
- From this study it needs to considering appropriate land use policy and proper nutrient management practices for increasing soil sustainability and productivity
- Depth wise study of total and DTPA-Zn, Cu, Mn and Fe in the soil must be conducted to evaluate the concentration of different DTPA-Zn, Cu, Mn and Fe in lower horizons of the soils.
- It is important to generate more information on the critical limits of DTPA-Zn, Cu, Mn and Fe for the area of soil groups under climatic conditions and an attempt to make to correlate macro and micro nutrient contents of the soil characteristics.
- Soil nutrient maps can be more authenticated by covering more villages and increased number of samples or applying krigging technology.

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APPENDIX –I

Physico-chemical properties and micronutrients (Zn, Fe, Cu, Mn and B) of Morar block.

Villages	Sample no.	pH	EC (dS/m)	OC (gkg^{1})	Available (kg/ha)				Micronutrients ($mg\ kg^{-1}$)				
					N	P	K	S	Zn	Cu	Fe	Mn	B
Susera	S-1	7.80	0.47	4.20	168	17.60	185.90	24.00	0.20	1.40	4.10	6.44	1.90
	S-2	7.60	0.46	3.60	162	20.90	171.30	19.10	0.48	1.20	2.30	5.10	2.10
	S-3	7.20	0.31	4.20	168	14.30	222.80	15.70	0.55	1.40	2.40	4.10	2.25
	S-4	8.10	0.52	4.30	172	16.00	171.30	18.80	0.70	1.50	4.20	8.30	2.85
	S-5	7.90	0.54	4.30	172	18.70	300.10	20.30	0.53	1.30	3.20	8.24	1.97
	S-6	8.10	0.54	4.00	180	25.30	164.60	17.50	0.38	1.40	7.90	3.26	3.22
	S-7	7.10	0.36	4.60	184	24.20	293.40	32.10	0.80	2.30	3.70	4.20	4.66
	S-8	7.80	0.48	4.60	184	24.20	293.40	30.0	0.44	2.10	7.80	4.99	1.90
	S-9	7.70	0.53	4.80	192	20.70	135.50	28.90	0.35	1.90	9.90	4.14	2.90
	S-10	8.10	0.34	3.70	166	23.90	166	28.00	0.6	3.2	4.6	6.42	1.85
Bhadroli	S-11	7.30	0.32	4.80	192	18.8	330.40	27.80	1.1	1.9	11.1	7.66	1.79
	S-12	7.10	0.43	5.40	202	19.00	573.40	19.80	0.33	1.8	10.29	5.22	3.02
	S-13	8.40	0.54	5.50	206	21.90	132.10	22.30	0.29	1.4	12.4	7.02	2.66

	S-14	7.44	0.28	4.00	190.0	44.47	247.36	9.04	0.36	0.12	7.44	8.76	2.45
	S-15	7.36	0.42	5.40	216.0	37.53	254.25	9.49	1.57	0.25	8.23	9.55	1.16
	S-16	7.77	0.45	5.70	228.0	43.59	268.21	9.19	1.97	0.25	6.98	8.30	2.47
Jalalpur	S-17	8.90	0.44	3.60	162.00	20.60	197.10	16.20	0.98	2.00	10.8	7.70	1.90
Milawali	S-18	7.30	0.35	3.10	139.00	23.10	644.00	37.70	0.95	2.71	5.20	2.71	1.85
	S-19	7.70	0.53	4.00	180.00	10.70	449.10	25.40	1.00	2.80	13.90	2.95	1.95
	S-20	7.60	0.33	4.30	172.00	14.70	479.30	35.00	0.53	2.70	10.21	3.24	2.10
	S-21	8.10	0.56	4.00	180.00	15.70	708.80	28.40	3.80	2.90	16.17	6.21	3.25
	S-22	7.90	0.47	3.60	162.00	22.50	536.40	32.40	1.20	2.42	26.9	5.92	4.10
	S-23	7.20	0.36	3.40	153.00	24.70	594.7	24.00	8.40	3.36	15.14	6.70	1.90
	S-24	7.60	0.42	3.20	144.00	17.50	708.90	31.30	1.40	2.40	29.20	8.02	2.50
	S-25	7.70	0.53	3.20	139.00	18.90	467.00	19.30	0.81	2.40	21.2	6.77	2.66
	S-26	8.10	0.49	4.60	184.00	11.60	651.80	21.60	0.79	4.20	10.9	3.29	1.9
	S-27	8.30	0.62	3.40	153.00	22.30	209.40	17.00	1.20	2.90	8.04	3.44	2.55
	S-28	7.20	0.31	3.60	162.00	18.70	524.80	20.80	0.90	2.46	5.35	8.10	3.21
	S-29	8.20	0.46	3.30	148.00	25.80	413.20	28.80	1.20	1.59	4.99	5.90	4.46
Jamahar	S-30	8.20	0.48	4.20	168.00	16.00	225.10	33.00	1.20	1.60	9.29	6.54	2.57
	S-31	7.60	0.39	4.60	184.00	14.70	423.30	15.70	0.95	2.80	7.25	7.43	2.85
	S-32	7.70	0.53	5.20	195.00	20.80	443.50	24.40	1.00	2.20	6.32	7.44	3.10

	S-33	8.20	0.44	4.60	184.00	23.90	193.70	24.00	1.20	2.40	6.47	5.40	4.60
Madanpur	S-34	7.20	0.36	4.80	192.00	23.10	575.60	32.30	0.97	3.20	6.25	7.20	2.77
	S-35	7.70	0.41	4.20	168.00	14.64	328.80	25.70	1.03	2.32	7.20	7.11	2.46
	S-36	8.10	0.54	3.40	153.00	32.50	386.40	32.30	1.40	2.40	13.40	5.99	2.55
	S-37	7.80	0.48	5.50	206.20	20.08	545.40	30.80	1.60	1.40	9.40	7.22	1.97
	S-38	7.40	0.37	5.20	195.00	19.20	555.50	18.30	1.60	2.30	7.40	4.99	3.20
Rudrapura	S-39	7.50	0.44	3.40	153	17.60	601.40	14.40	0.90	2.10	6.80	5.90	3.10
	S-40	7.5	0.48	3.90	175.50	17.30	496.80	31.70	0.44	1.00	5.40	7.22	4.60
	S-41	7.60	0.47	6.10	228.70	15.50	563.30	18.40	0.49	1.20	6.20	5.72	3.10
	S-42	7.07	0.51	4.20	168.00	14.60	508.40	21.80	0.33	2.20	4.20	7.06	2.10
	S-43	7.80	0.63	3.60	162.00	22.84	595.80	14.00	0.70	1.40	2.40	7.42	3.95
Rai	S-44	8.50	0.45	3.90	163.00	14.77	181.40	60.60	0.96	2.10	6.87	5.95	2.35
	S-45	8.70	0.62	4.30	200.70	13.45	228.40	42.80	0.44	1.00	5.91	7.34	3.80
	S-46	8.20	0.54	4.00	137.90	10.65	210.50	44.90	0.44	1.30	17.85	4.72	3.89
	S-47	8.70	0.63	4.20	150.50	12.94	272.10	68.00	0.31	2.40	4.30	8.06	3.09
	S-48	7.10	0.32	3.60	100.30	10.80	333.70	22.50	0.82	1.20	2.62	7.81	2.66
Berja	S-49	7.90	0.47	4.10	137.90	11.26	305.70	62.60	0.38	1.20	3.44	3.56	3.74
	S-50	7.80	0.51	4.20	137.10	13.78	301.20	26.60	0.82	2.20	8.97	4.50	3.80
	S-51	7.40	0.39	3.90	163.00	9.05	219.50	41.60	1.20	2.40	1.41	5.48	5.66

	S-52	8.10	0.55	4.40	150.50	21.52	234.00	33.10	0.49	2.30	3.74	4.97	5.77
	S-53	8.4	0.49	3.40	175.50	9.23	120.90	31.80	0.35	1.90	8.8	5.14	4.12
Gowai	S-54	7.2	0.32	4.00	137.90	8.25	319.20	12.30	1.00	1.40	4.05	7.63	5.24
	S-55	7.4	0.36	3.70	150.50	19.10	367.30	42.20	0.58	1.40	2.46	5.15	5.86
	S-56	7.3	0.34	4.20	112.80	9.04	301.20	35.50	0.80	1.50	4.27	8.35	5.84
	S-57	7.2	0.29	4.40	100.30	11.80	375.20	12.80	0.53	1.40	18.52	5.24	4.12
	S-58	7.7	0.54	4.30	163.00	16.60	361.70	41.40	1.10	1.90	24.10	7.66	4.52
Supawali	S-59	7.8	0.39	4.60	150.50	11.90	199.30	39.40	0.29	1.80	18.79	5.53	4.92
	S-60	7.9	0.44	3.60	137.90	13.96	471.50	36.10	0.33	2.00	10.08	7.32	2.57
	S-61	7.8	0.52	3.90	175.6	16.5	250.80	36.00	0.29	1.40	29.79	7.70	3.98
	S-62	7.7	0.48	4.00	150.500	21.11	428.90	40.50	2.90	1.60	11.84	6.54	5.82
	S-63	7.4	0.28	4.40	163.00	15.4	333.70	27.20	0.87	2.20	9.29	7.63	4.03
Khureri	S-64	7.7	0.41	3.90	213.20	10.13	417.70	55.80	0.98	3.80	7.25	5.30	4.72
	S-65	7.8	0.56	3.70	225.70	8.96	288.90	40.50	1.40	2.10	7.99	6.22	4.18
	S-66	7.5	0.38	4.40	112.80	11.06	371.80	62.70	1.40	2.80	14.4	8.04	4.65
	S-67	7.6	0.42	4.00	175.60	13.50	403.20	43.30	1.50	1.80	10.44	7.79	4.81
	S-68	7.3	0.29	4.10	137.90	9.46	523.00	45.60	1.20	2.90	6.47	5.77	3.98
Akabarpur	S-69	7.69	0.40	5.20	208.06	33.02	215.20	20.70	0.68	0.35	6.57	7.89	3.21
	S-70	8.02	0.32	4.40	198.05	33.52	269.35	20.10	0.36	0.27	5.82	7.14	3.12

	S-71	8.19	0.42	5.40	216.06	43.40	278.36	21.60	0.27	0.12	6.83	8.15	2.14
	S-72	7.69	0.31	4.30	193.55	43.40	278.36	19.90	0.69	0.26	9.64	9.76	2.31
	S-73	7.86	0.32	4.40	198.05	33.48	258.24	21.90	0.28	0.27	7.42	8.74	2.24
	S-74	7.28	0.28	4.00	190.04	33.47	257.32	20.70	0.30	0.23	6.38	7.70	3.04
	S-75	7.36	0.38	5.00	225.0	33.45	245.32	23.40	0.61	0.33	7.48	8.80	2.25
	S-76	7.77	0.38	5.00	225.06	32.93	285.74	22.00	0.22	0.33	8.57	9.89	1.35
	S-77	7.53	0.54	5.10	204.06	43.47	232.65	20.4	0.26	0.24	9.11	9.23	2.45
	S-78	7.25	0.34	4.60	207.06	32.76	267.25	21.5	0.30	0.29	8.58	9.90	3.21
Khedi	S-79	7.69	0.45	5.70	228.06	33.49	271.65	15.40	1.43	0.15	8.44	9.76	2.45
	S-80	8.19	0.37	4.90	220.56	33.66	254.25	13.70	0.22	0.32	8.78	10.10	2.63
	S-81	7.94	0.29	4.10	184.55	43.47	257.32	16.50	0.36	0.24	7.41	8.73	2.74
	S-82	7.61	0.36	4.80	216.06	33.72	246.36	15.70	0.42	0.31	8.22	9.54	2.47
	S-83	7.86	0.28	4.00	190.04	37.79	245.24	17.40	0.43	0.23	7.46	8.78	2.42
Ikhara	S-84	7.69	0.47	5.90	236.06	45.05	258.32	17.40	0.44	0.21	6.65	7.97	3.21
	S-85	7.77	0.41	5.30	212.06	37.69	246.52	23.40	0.32	0.11	8.71	10.03	2.29
	S-86	7.2	0.27	3.90	185.20	35.76	247.41	21.60	0.28	0.22	6.44	7.76	3.06
	S-87	7.69	0.31	4.30	193.50	38.46	244.87	16.40	0.96	0.26	7.65	8.97	2.47
	S-88	7.68	0.35	4.70	211.50	45.10	242.36	15.60	1.02	0.30	6.85	8.17	3.11
	S-89	7.53	0.45	5.70	228.00	33.52	272.36	12.90	0.62	0.15	9.02	9.14	3.45

	S-90	7.77	0.27	3.90	185.20	43.55	275.25	10.20	0.28	0.22	8.55	9.87	3.41

Appendix-II

Physico-chemical properties and micronutrients (Zn, Fe, Cu, Mn and B) of Dabra block.

Villages	Sample no.	pH	EC (dm^{-1})	OC (gkg^{-1})	Available (kg/ha)				Micronutrients				
					N	P	K	S	Zn	Cu	Fe	Mn	B
Samudan	S-1	7.1	0.41	4.60	175.60	19.14	337.60	55.70	1.20	2.97	11.60	3.50	4.33
	S-2	7.9	0.53	6.60	163.00	10.12	307.70	17.80	0.44	2.66	12.00	4.60	3.30
	S-3	7.6	0.46	5.50	150.50	16.12	251.60	44.90	0.49	1.38	18.50	2.90	4.10
	S-4	7.4	0.34	4.30	188.10	13.52	446.80	14.70	0.40	1.50	8.66	5.10	3.95
	S-5	8.4	0.52	5.20	150.50	10.65	301.00	8.66	1.80	1.61	7.80	3.80	2.90
Ptha-panihar	S-6	7.1	0.29	6.10	200.70	11.20	367.30	15.40	0.56	3.58	14.20	5.60	5.10
	S-7	7.3	0.52	5.10	175.60	22.70	173.40	36.30	2.90	2.01	16.20	3.20	5.60
	S-8	7.6	0.31	4.30	200.70	20.50	234.00	26.50	1.10	2.18	9.10	4.30	6.22
	S-9	7.7	0.42	4.60	137.90	14.52	281.30	41.30	0.91	2.03	29.70	6.10	6.29
	S-10	8.5	0.49	5.50	150.50	22.70	229.40	8.97	0.73	3.78	27.30	3.50	4.25
Simariya-takeri	S-11	8.3	0.49	6.60	163.00	20.60	300.10	34.50	1.70	4.09	13.80	5.10	4.52

	S-12	8.5	0.54	4.30	112.80	19.00	207.80	7.25	0.33	2.10	9.60	4.90	5.77
	S-13	8.3	0.51	4.80	163.00	12.27	194.80	8.02	2.90	3.62	14.80	2.60	6.21
	S-14	8.1	0.61	6.10	213.20	10.67	249.70	19.10	1.60	1.30	15.00	4.30	3.22
	S-15	7.5	0.44	5.20	175.60	13.92	539.80	5.24	0.53	2.71	19.40	4.20	4.25
Akabai-badi	S-16	8.2	0.36	5.10	150.50	22.90	265.40	5.24	1.00	2.62	15.00	5.10	5.60
	S-17	7.9	0.44	6.30	188.10	22.60	191.90	4.25	0.80	3.42	21.36	3.40	4.50
	S-18	8.1	0.51	5.40	163.00	9.60	225.60	6.38	1.00	2.69	13.88	4.30	4.10
	S-19	7.9	0.62	4.30	175.60	17.9	234	28.30	1.20	2.46	8.73	5.30	3.90
	S-20	7.7	0.56	4.80	112.80	11.18	286.7	14.20	1.50	2.06	6.98	4.60	4.50
Salaiya	S-21	8.5	0.46	4.20	137.90	13.36	127.5	8.55	2.60	2.50	9.40	4.50	6.10
	S-22	8.1	0.47	6.30	150.50	12.87	364.00	16.50	2.20	4.03	16.80	3.90	5.25
	S-23	7.7	0.61	5.10	163.00	10.58	163.40	36.30	2.60	2.13	8.31	4.20	6.29
	S-24	7.9	0.63	4.00	188.10	17.35	290.00	38.5	4.20	1.49	10.61	5.30	4.40
	S-25	7.6	0.53	6.10	163.00	13.64	460.30	40.50	2.60	1.14	11.64	4.60	3.80
Masaudpur	S-26	7.7	0.61	7.80	175.60	15.90	362.80	7.92	0.90	2.41	6.40	4.10	4.60
	S-27	7.6	0.51	4.90	200.70	9.37	563.30	14.80	1.30	1.21	21.28	6.90	2.90
	S-28	7.2	0.42	6.30	188.10	16.50	520.80	10.80	1.10	0.99	18.31	8.10	2.40
	S-29	7.8	0.38	4.00	200.70	18.90	688.80	22.30	1.90	1.10	18.88	6.30	1.90
	S-30	7.8	0.31	5.10	175.60	15.80	260.50	16.30	1.70	2.58	14.40	5.90	3.80

Appendix-III

Physico-chemical properties and micronutrients (Zn, Fe, Cu, Mn and B) of Bhitarwar block.

Villages	Sample no.	pH	EC(dSm^{-1})	OC (gkg^{-1})	Available (kg/ha)				Micronutrients				
					N	P	K	S	Zn	Cu	Fe	Mn	B
Antari	S-1	7.5	0.44	3.70	125.40	10.88	294.50	32.50	0.80	2.10	27.10	5.30	4.72
	S-2	7.5	0.39	4.20	100.30	17.61	306.8	13.80	0.80	2.40	7.54	6.22	4.18
	S-3	7.8	0.56	4.30	125.40	12.31	244.10	4.17	1.00	2.30	25.93	8.04	4.65
	S-4	7.7	0.46	3.90	112.80	15.10	278.80	25.30	1.00	2.20	10.88	7.79	4.81
	S-5	7.5	0.43	4.00	150.50	18.30	312.40	61.30	0.73	2.30	8.96	5.77	3.98
achhaua	S-6	7.9	0.43	4.10	75.20	22.62	162.40	24.10	1.81	3.04	22.98	6.22	5.04
	S-7	7.9	0.34	4.30	125.40	19.72	255.30	13.20	2.51	2.00	12.83	3.49	5.89
	S-8	7.6	0.28	4.80	175.60	18.20	178.10	18.00	2.15	3.80	21.3	5.77	6.22
	S-9	7.7	0.51	4.20	137.90	16.80	313.60	40.10	1.2	3.80	28.38	8.55	6.29
	S-10	7.9	0.62	3.60	112.80	11.27	240.80	34.30	0.51	3.70	29.36	2.91	4.27
Pipraua	S-11	6.5	0.24	3.60	150.50	10.50	286.70	20.50	1.36	1.70	8.26	8.60	5.66
	S-12	7.7	0.49	4.30	263.40	15.10	163.50	63.40	0.98	2.10	9.04	9.96	4.72
	S-13	7.6	0.37	3.70	137.90	10.20	227.30	64.60	0.53	3.10	2.37	5.57	4.41

	S-14	7.8	0.51	4.80	112.80	16.90	174.70	14.40	0.71	1.70	24.86	10.25	3.29
	S-15	7.4	0.39	4.00	120.50	8.30	199.30	55.60	0.8	2.60	29.99	6.10	4.83
Prempur	S-16	7.4	0.42	3.7	87.80	11.07	174.70	27.60	2.95	2.90	36.78	9.00	3.49
	S-17	8.3	0.46	4.00	137.90	10.90	285.60	48.50	3.13	2.90	19.46	23.97	5.10
	S-18	8.2	0.49	4.30	100.30	15.50	218.40	14.80	2.53	2.90	16.93	21.90	6.02
	S-19	7.9	0.53	4.80	137.90	13.80	244.10	16.50	1.14	3.10	10.19	8.15	4.79
	S-20	7.9	0.46	3.90	87.80	19.09	258.70	26.10	1.34	3.10	13.66	7.39	2.86
Bdagisaray	S-21	7.9	0.31	3.90	125.40	8.74	424.40	40.30	0.53	2.90	19.84	7.84	3.47
	S-22	8.0	0.51	3.70	200.30	9.22	329.20	60.60	0.51	1.90	17.47	10.3	4.52
	S-23	8.3	0.62	3.80	187.80	11.71	163.40	3.15	0.8	3.30	23.78	8.08	3.47
	S-24	8.1	0.54	4.00	100.30	11.08	334.40	16.00	0.47	2.00	12.76	10.6	3.60
	S-25	8.2	0.44	4.20	275.20	16.4	174.70	53.50	0.64	0.44	9.67	7.80	4.00
Shivnagar	S-26	7.5	0.34	4.80	216.00	33.54	211.00	24.70	0.46	0.29	5.20	6.52	2.80
	S-27	7.39	0.32	4.70	211.50	33.64	208.00	23.90	0.75	0.27	5.60	6.92	5.33
	S-28	7.6	0.42	5.20	234.00	43.43	221.00	24.20	1.16	0.22	5.30	6.62	3.03
	S-29	7.45	0.33	5.10	229.50	36.86	227.00	25.3	1.3	0.28	6.20	7.52	3.08
	S-30	7.2	0.43	4.60	207.00	32.76	177.00	20.1	1.53	0.13	7.20	8.52	4.96
Amrol	S-31	8.02	0.59	4.80	218.30	44.13	214.50	25.6	0.67	0.29	8.10	9.42	3.30
	S-32	7.81	0.63	4.00	180.00	47.15	299.00	14.70	1.50	0.33	6.60	7.92	2.25

	S-33	7.62	0.66	5.70	257.1	32.84	268.8	13.00	0.75	0.36	4.80	5.92	1.01
	S-34	7.76	0.65	5.20	237.9	42.55	407.7	11.20	0.38	0.35	8.10	9.42	1.79
	S-35	7.56	0.67	5.70	257.1	33.04	442.4	14.6	0.39	0.37	7.36	8.68	1.47
	S-36	7.98	0.64	6.10	275.9	56.43	379.7	13.00	0.49	0.34	7.42	8.74	1.38
	S-37	7.91	0.71	4.00	184.10	33.00	313.80	15.50	0.3	0.41	6.35	7.67	1.74
	S-38	8.02	0.70	3.60	162.90	56.43	269.90	15.60	0.29	0.40	8.72	10.04	1.38
	S-39	8.13	0.60	5.00	226.80	40.84	275.50	14.70	0.75	0.30	9.57	9.69	1.51
	S-40	8.10	0.66	4.00	184.10	51.79	202.70	15.70	0.5	0.36	8.25	9.57	2.11
	S-41	8.16	0.61	3.20	147.60	51.79	194.90	19.90	0.49	0.31	8.74	10.06	1.38
	S-42	7.38	0.18	3.90	175.50	48.39	228.48	15.70	0.38	0.13	7.77	9.09	1.50
	S-43	7.43	0.28	4.20	189.00	38.64	192.64	10.00	0.3	0.23	6.41	7.73	2.16
	S-44	8.11	0.32	3.40	153.00	40.12	178.8	9.50	0.26	0.27	7.42	8.74	2.02
Nikodi	S-45	8.16	0.61	3.20	147.60	51.79	194.9	19.90	1.58	0.31	7.84	9.16	1.58
	S-46	7.66	0.62	5.00	225.00	32.94	207.20	12.70	1.41	0.32	6.52	7.84	2.64
	S-47	7.56	0.67	5.70	257.10	33.04	442.40	15.40	0.47	0.37	5.67	6.99	1.11
	S-48	7.59	0.61	6.00	270.00	40.82	286.70	14.50	0.26	0.31	7.18	8.50	1.32
	S-49	7.9	0.70	5.70	257.40	33.39	194.40	20.70	1.04	0.40	7.86	9.18	1.60
	S-50	8.07	0.58	5.10	233.10	42.51	282.30	13.90	1.64	0.28	9.25	9.37	2.05
	S-51	7.71	0.66	6.80	308.70	58.75	293.4	16.00	1.77	0.36	7.42	8.74	2.12

	S-52	7.8	0.52	4.80	278.00	33.24	245.00	18.00	0.41	0.22	7.48	8.8	1.47
	S-53	7.42	0.41	4.60	274.00	32.74	178.00	15.00	0.63	0.11	6.87	8.19	1.24
	S-54	7.5	0.43	4.80	268.32	33.04	188.00	19.80	0.3	0.13	7.22	8.54	1.36
	S-55	7.3	0.29	4.60	245.25	43.47	168.75	16.00	0.24	0.24	7.44	8.76	2.03
	S-56	7.4	0.36	4.90	269.22	33.47	188.25	13.60	1.58	0.31	6.58	7.90	3.21
	S-57	7.7	0.45	4.70	245.45	33.52	245.24	16.70	1.49	0.15	9.87	9.99	2.84
	S-58	7.45	0.55	4.90	248.55	33.54	260.32	19.80	0.58	0.25	9.94	10.06	2.17
	S-59	7.72	0.60	4.80	255.25	43.37	235.58	15.40	0.57	0.30	8.74	10.06	3.25
	S-60	7.78	0.42	4.90	268.32	33.49	178.55	20.70	0.38	0.12	6.37	7.69	3.28
	S-61	7.67	0.35	4.70	260.25	32.80	188.26	15.70	0.23	0.30	5.87	7.19	1.32
	S-62	7.55	0.39	4.90	288.32	43.78	220.15	19.80	1.82	0.34	7.48	8.80	2.36
	S-63	7.78	0.45	21.40	220.45	44.49	178.45	12.70	0.29	0.15	7.39	8.71	2.14
	S-64	7.92	0.56	4.80	198.25	32.8	168.65	15.40	1.25	0.26	8.88	10.20	1.67
	S-65	7.45	0.42	4.90	220.56	33.49	185.54	18.9	0.54	0.12	7.87	9.19	2.14
	S-66	7.65	0.54	4.80	165.25	32.8	189.25	16.5	0.22	0.24	7.48	8.80	1.65
	S-67	7.65	0.59	4.70	137.45	32.87	230.15	14.9	0.44	0.29	6.57	7.89	1.37
	S-68	7.72	0.57	4.80	129.58	33.69	288.26	18.0	0.49	0.27	7.58	8.9	2.11
	S-69	7.25	0.38	4.70	255.26	33.59	245.56	13.0	0.31	0.33	7.47	8.79	1.46
	S-70	7.82	0.47	4.90	268.15	32.76	278.58	15.3	0.23	0.17	6.34	7.66	1.44

	S-71	7.92	0.62	4.80	248.58	32.8	246.47	11.7	0.25	0.32	8.23	9.55	2.05
	S-72	7.45	0.41	5.20	282.54	33.71	288.23	16.7	0.43	0.11	7.48	8.80	3.57
	S-73	7.95	0.68	4.70	275.64	44.11	290.45	20.7	0.43	0.38	7.68	9.00	3.44
	S-74	7.89	0.55	4.60	225.56	33.49	284.24	13.90	0.27	0.25	5.63	6.95	3.12
	S-75	7.77	0.45	4.80	256	44.81	245.56	15.70	1.42	0.15	7.11	8.43	1.88
	S-76	7.65	0.67	4.90	220.26	32.89	225.85	12.80	0.28	0.37	7.48	8.8	1.42
	S-77	7.58	0.42	4.80	256.85	44.18	265.45	16.40	0.33	0.12	6.53	7.85	1.32
Mauch	S-78	7.95	0.75	4.60	210.25	33.49	255.21	15.40	1.39	0.45	7.35	8.67	2.47
	S-79	7.65	0.42	4.90	245.48	35.77	165.35	20.70	0.28	0.12	8.26	9.58	2.89
	S-80	7.72	0.54	4.80	255.56	33.19	245.56	16.50	0.32	0.24	7.22	8.54	2.46

Appendix-iv

Physico-chemical properties and micronutrients (Zn, Fe, Cu, Mn and B) of Ghatigaon block.

Villages	Sample no.	pH	EC (dS/m)	OC (gkg1)	Available (kg/ha)				Micronutrients (mg kg^{-1})				
					N	P	K	S	Zn	Cu	Fe	Mn	B
Raipur khurd	S-1	7.4	0.31	4.20	150.5	21.76	226.10	21.50	0.94	2.21	24.25	5.10	2.50
	S-2	7.9	0.42	6.60	112.8	10.69	344.90	38.90	0.47	1.93	13.19	6.20	3.25
	S-3	7.3	0.32	4.60	163.00	12.70	151.20	39.40	0.35	1.38	10.75	7.30	3.10
	S-4	7.5	0.29	3.70	137.90	8.47	241.60	14.20	1.00	3.39	18.78	4.30	4.10
	S-5	7.4	0.35	5.70	150.5	15.19	274.40	44.90	0.49	1.09	10.08	5.10	6.22
Kanker	S-6	7.1	0.27	4.30	87.80	18.50	315.50	27.10	1.32	3.06	11.84	6.10	3.90
	S-7	7.2	0.34	5.10	163.00	6.03	376.30	40.90	0.66	2.80	9.29	7.04	2.57
	S-8	7.3	0.37	4.60	137.90	18.76	521.90	14.50	1.60	3.80	7.57	8.10	2.46
	S-9	7.7	0.43	6.60	175.60	10.88	317.90	16.00	0.64	2.60	17.56	4.60	1.95
	S-10	7.6	0.41	6.10	150.50	19.16	181.80	23.30	1.90	2.66	12.38	6.40	3.20
Raipur kla	S-11	7.6	0.54	4.30	112.80	11.80	295.10	38.10	0.95	2.71	30.10	5.20	3.00
	S-12	7.9	0.61	5.10	200.70	12.41	296.30	41.40	1.00	2.95	16.39	3.90	4.60

	S-13	7.9	0.53	4.20	163.00	16.90	261.90	3.97	0.53	3.44	5.35	4.50	2.95
	S-14	7.8	0.45	6.60	137.90	9.61	368.40	16.00	3.80	3.36	5.30	4.60	1.99
	S-15	8.1	0.51	4.20	150.50	10.74	464.80	38.8	1.10	2.24	8.04	5.90	3.55
Barai	S-16	8.3	0.47	6.10	175.60	14.54	377.4	23.9	0.87	4.25	26.61	8.30	2.57
	S-17	8.1	0.49	4.80	137.90	17.05	367.3	12.8	1.30	2.64	10.90	7.20	1.85
	S-18	7.9	0.56	6.10	150.50	15.08	491.6	17.3	0.71	2.21	15.47	3.90	3.25
	S-19	8.1	0.47	4.00	137.90	6.30	632.8	34.6	0.80	2.47	13.01	5.90	4.60
	S-20	8.1	0.51	7.60	163.00	13.08	314.7	30.60	1.10	1.58	8.03	8.10	6.10
Jigsoli	S-21	8.2	0.44	4.20	175.60	14.90	353.9	28.60	1.20	3.44	10.37	4.80	3.50
	S-22	7.9	0.55	4.80	137.90	7.42	214.8	13.90	0.69	2.49	16.10	5.60	4.60
	S-23	8.1	0.51	4.20	175.60	17.40	175.8	4.11	1.10	3.15	5.91	7.10	3.90
	S-24	8.3	0.46	6.60	163.00	12.00	449.9	24.50	0.64	2.65	110	6.40	5.10
	S-25	7.4	0.37	6.30	137.90	15.80	163.2	39.10	1.10	3.25	25.4	5.60	5.24
Kheriyakhacha	S-26	7.41	0.4	4.30	193.50	44.15	219.52	10.30	0.26	0.35	8.19	9.51	2.66
	S-27	7.48	0.65	3.80	171.00	35.46	183.68	14.70	0.25	0.35	8.87	10.19	2.34
	S-28	7.83	0.26	3.60	162.00	46.27	189.28	17.50	0.25	0.21	7.48	8.80	2.11
	S-29	7.48	0.86	3.80	171.00	38.64	193.26	13.00	0.26	0.56	8.63	9.95	0.87
	S-30	8.00	0.65	4.70	211.50	44.95	226.24	16.40	0.3	0.35	7.48	8.80	1.42
	S-31	7.9	0.35	3.50	157.50	38.64	322.56	19.80	0.28	0.3	7.84	9.16	2.85

	S-32	7.42	0.66	3.50	157.50	33.54	182.56	10.00	0.32	0.36	8.24	9.56	1.27
	S-33	8.02	0.59	4.80	218.30	44.13	214.50	14.90	0.28	0.29	8.47	9.79	1.38
	S-34	7.81	0.63	4.00	180.00	47.15	299.00	15.40	0.36	0.33	4.72	5.84	2.11
Khusrajpur	S-35	7.8	0.54	4.1	184.5	43.46	167	20.9	0.72	0.24	4.80	5.92	3.31
	S-36	7.7	0.48	6.4	289.3	33.24	387.5	21.9	0.52	0.28	6.70	8.02	3.22
	S-37	7.8	0.56	7	319.1	43.12	173.6	23.7	0.67	0.26	5.42	6.74	2.89
	S-38	8.05	0.67	2.70	122.4	44.32	257.60	23.50	1.19	0.37	7.41	8.73	3.30
	S-39	7.8	0.54	5.40	185.00	43.10	184.20	20.90	0.72	0.25	4.10	5.92	3.20
	S-40	7.6	0.48	4.60	289.00	33.10	289.30	21.80	0.52	0.29	6.20	8.20	3.72
	S-41	7.5	0.56	4.60	319.10	44.20	319.15	23.50	1.14	0.26	5.30	8.20	2.19
	S-42	7.3	0.67	6.50	122.30	32.10	387.00	25.50	0.67	0.39	4.50	8.73	2.89
	S-43	7.6	0.59	2.70	218.30	30.10	299.00	14.60	1.50	0.33	6.70	9.40	1.90
	S-44	7.9	0.63	4.10	180.10	44.10	257.00	13.00	0.75	0.24	4.80	5.92	1.79
	S-45	7	0.66	4.90	257.00	38.20	260.00	10.80	1.10	0.28	8.10	10.7	1.47
	S-46	7.4	0.46	4.90	256.20	9.55	245.20	18.40	0.46	0.29	5.50	2.80	1.20
	S-47	7.7	0.66	5.00	245.30	19.10	255.00	15.70	0.23	0.50	4.78	5.10	1.59
	S-48	7.5	0.54	4.60	255.30	22.21	246.13	20.80	0.46	0.95	5.43	7.33	2.21
	S-49	8.1	0.34	5.20	234.21	34.23	254.56	17.20	0.42	1.10	6.40	4.60	1.34
	S-50	7.6	0.49	5.50	259.43	18.54	319.87	21.50	0.32	2.30	7.55	8.40	3.21

VITA

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