CHARACTERIZATION OF SOIL AND WATER QUALITY PARAMETERS OF CUDDAPAH BLOCK IN YSR DISTRICT OF ANDHRA PRADESH

काशी हिन्दू विश्वविद्यालय
BANARAS HINDU UNIVERSITY

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF

Master of Science (Agriculture)

in

Soil Science - Soil and Water Conservation

Supervisor
Dr. Ramawatar Meena

Submitted by
Varadaraju Viveka

Department of Soil Science & Agricultural Chemistry
Institute of Agricultural Sciences
Banaras Hindu University
Varanasi 221005
India

ID. No. 19430SAC018 2021 Enrolment No. 417410

Dr. R. Meena
Assistant Professor
Mobile: 9598304957
E-mail: rmeena78@gmail..com
U.P. (INDIA)

Department of Soil Science and Agricultural Chemistry
Institute of Agricultural Sciences
Banaras Hindu University
Varanasi-221005

CERTIFICATE

To
The Joint Registrar (Academic),
Office of the Registrar,
Banaras Hindu University,
Varanasi – 221 005 (India).

Sir,

I have great pleasure in forwarding the thesis entitled **"Characterization of soil and water quality parameters of Cuddapah block in YSR district of Andhra Pradesh"** submitted by **Miss Varadaraju Viveka** (ID No: 19430SAC018) in partial fulfilment of the requirements for the award of the degree of ***Master of Science (Agriculture)*** *in* ***Soil Science – Soil and Water Conservation***, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University.

I certify that the entire scheme of investigation reported here in, was planned and carried out by the candidate under my guidance. To the best of my knowledge and belief, the data presented in the thesis are genuine and original. No part of the work has been submitted for any degree or distinction.

Thanking you,

Forwarded	Forwarded	Yours sincerely
Head	**(Course Coordinator)**	**(Dr. Ramawatar Meena)** **Chairman of the Advisory Committee**

Characterization of soil and water quality parameters of Cuddapah block in YSR district of Andhra Pradesh

By

Varadaraju Viveka

ID. No. 19430SAC018 **2021** **Enrolment No. 417410**

Thesis submitted in partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

in

Soil Science – Soil and Water Conservation

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
INSTITUTE OF AGRICULTURAL SCIENCES
BANARAS HINDU UNIVERSITY
VARANASI- 221 005
INDIA

APPROVED BY ADVISORY COMMITTEE

Chairman	**Dr. Ramawatar Meena** **Assistant Professor** Department of Soil Science & Agricultural Chemistry, Institute of Agricultural Sciences, B.H.U., Varanasi-221005
Co-Chairman	**Dr. Y.V. Singh** **Associate Professor** Department of Soil Science & Agricultural Chemistry, Institute of Agricultural Sciences, B.H.U., Varanasi-221005
Member	**Dr. Ashish M Latare** **Assistant Professor** Department of Soil Science & Agricultural Chemistry, R.G.S.C., Barkkachha, Mirzapur
Member	**Mr. Pawan Kumar Anand** **Asst. Professor (Horticulture)** R.G.S.C., Barkkachha, Mirzapur.
External Examiner	

ACKNOWLEDGEMENT

I bow my head before the feet of the "Lord Shiva", the "Almighty" due to whose blessings I am able to reach at this stage and I feel that everything on this earth could be possible only with the blessings of this invisible but omnipresent supreme force.

At the outset, being the student of this great Institute, I bow my head with great reverence to the lotus feet of ***Bharat Ratna Mahamana Pandit Madan Mohan Malaviya Ji,*** *the founder of the Banaras Hindu University, whose everlasting desire was to serve mankind. I am fortunate to perceive the prodigious path to tread upon precisely through precious guidance in this university.*

I would like to express my profound sense of reverence and indebtedness to my Supervisor, ***Dr. Ramawatar Meena****, Assistant Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University for his meticulous guidance, compassionate initiation, congenial discussion, constructive criticism and soothing affection during the course of this investigation and preparation of this manuscript. It was a matter of sheer luck and opportunity to work under his guidance.*

A special word of acknowledgement for ***Prof. Nirmal De,*** *H.O.D (SWC) Soil Science & Agricultural Chemistry, Banaras Hindu University. Significant inputs from him have helped to enrich my work.*

I offer my heartfelt gratitude to ***Dr. Ashish M Latare*** *(Assistant Professor, Department of Soil Science and Agricultural Chemistry) R.G.S.C. (BHU) Barkkachha, Mirzapur, Institute of Agricultural Sciences, Banaras Hindu University for their constant encouragement, critical suggestions and inspiration during entire period of investigation and the members of the advisory committee* ***Dr. Y.V. Singh*** *Associate Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University,* ***Dr. Ashish M Latare*** *(Assistant Professor, Department of Soil Science and Agricultural Chemistry) R.G.S.C. (BHU) Barkkachha, Mirzapur, Institute of Agricultural Sciences, Banaras Hindu University. I would like to convey my gratitude to* ***Mr. Pawan Kumar Anand*** *(Horticulture), R.G.S.C. (BHU) Barkkachha, Mirzapur.*

I am grateful to ***Prof. A.P.Singh (Dean), Prof. S.K. Singh, Prof. S.Singh, Prof. P. Raha, Prof J.Yadav, Prof. A.K. Ghosh, Prof. P.K.Sharma and Dr. A. Rakshit****. I am thankful to non-teaching staff members of Department of Soil Science* *and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University for all kinds of help to me during my study period.*

*My special thanks to **Dr. Triyugi Nath, Dr. Savita Dewangan**, for their guidance, construction criticism, affectionate behavior and moral support during investigation of this research work.*

I would like to thank sincerely from the bottom of my heart to my dearest friends Panneeru Vennela, Thaiseen Tabasum, Tuli Taga, Divya, Krupa ,Vinod Prajapat, Thirumalesh Basam, Kanhaiya Gawande, Kalyan, Bhargavi and Sonal Sharma for their kind encouragement and support during the conduct of research as well as while writing thesis.

Words with me are insufficient to express my feelings of my heart to acknowledge my gratitude to my beloved mother Smt. Reddemma and my father Shri Balarama Raju. For their co-operation, inspiration and support in all the way and other family members who have providing all kinds of help and love.

Without the help of seniors none can learn the lesson of life and cannot teach the same to loving juniors. So, heartfelt and special thanks to my seniors for their cooperation during the study and investigation.

I would like to thank my juniors and others for always being supportive and helping and also thank to everyone who was involved in completing this work.

I would like to extend my sincere thanks to Sita Ram Yadav, Lab attendant, SS-SWC, RGSC, BHU. The thankfulness is also extended to Shri Shishir Kumar Singh, A.K. Sharma, Shri Agraj Kumar Pathak, Shri K.K.Singh and Shri Amaraendra for theur continuous help. Last but not the least, I record my sincere thanks to all beloved and respected people who helped and could not find separate mentions. I still solicit their benediction to proceed at every step of respected destined life.

It's like drop in the ocean by my all regards to Maa Vindhyavasini and Baba Vishwanath, for providing me energy and patience without which I would have been none.

Date:
Place: Varanasi *(Varadaraju Viveka)*

Contents

LIST OF SYMBOLS AND ABBREVIATIONS

%	Per cent
Agri.	Agriculture
B.D	Bulk density
BIS	Bureau of Indian standards
Ca	Calcium
cm	Centimeter
Cmol (P+) kg^{-1}	Centimol per kilogram
DSm^{-1}	Desisimen per meter
DTPA	Diethyline Triamine Penta acetic acid
EC	Electrical conductivity
EDTA	Ethylene di amine tetra acetic acid
Et al.	Et alia, and others
G kg^{-1}	Gram per kilogram
Ha.	Hectare
i.e.	Id est. that is
J	Journal
K	Potassium
Kg ha^{-1}	Kilogram per hectare
Meq $100g^{-1}$	Milli equivalents per 100 gram of soil
Mg	Magnesium
Mg kg^{-1}	Milligram per kilogram
Mha	Million hectare
Mm.	Millimeter
N	Nitrogen
Na	Sodium
NIV	Nutrient index value

O.C	Organic carbon
P	Phosphorus
P.D	Particle density
pH	Puissance de hydrogen
S	Sulphur
Fe	Iron
Mn	Manganese
Zn	Zinc
Cu	Copper
Sq. km	Square kilometer
viz.,	Vide licet, namely
WHC	Water holding capacity
WQI	Water quality index

LIST OF TABLES

LIST OF FIGURES

Chapter I

INTRODUCTION

Soil is a dynamic natural resource found on the earth surface. Soil develops on the earth's surface as a thin layer which is known as "pedosphere". This thin layer affects every part of ecosystem and acts as a "great integrator". Soil performs several important functions within an ecosystem and varies from one location to another location as a result of various factors including climatic differences, plant and animal life living on them, soil position on the land scape, soil topography and age of the soil. Soil performs several functions like it acts as a medium for plant growth , it helps in water purification, storage and supply, it plays an important role in modifications of atmosphere, it is a habitat for many organisms in decomposition of organic matter.

Soil fertility is the term which means the inherent capacity of soil to provide essential nutrients for plant growth and yield enhancement **(Tisdale *et al.* in 1993).** Soil fertility and Soil health plays a crucial role in sustainable agricultural production because these are soil chemical reactions, availability of essential nutrients, depletion of nutrients and their replenishment in soil. As the population is increasing in the country, it became a continuous pressure on soils leading to its degradation and making the soils gradually unsuitable for the crop cultivation.

So to feed the alarming population it is important to maintain soil fertility. Fertility of the soil varies both temporarily and spatially and influenced by both extrinsic and intrinsic factors **(Cambardella and Karlen, 1999, Ondersteijn *et al.* 2003).** Thus without prior knowledge on soil fertility status, it might have been resulted in adverse effects on both soils and crops in terms of nutrient deficiency and nutrient toxicity either due to adequate or over use of fertilizers.

There are 17 essential nutrients which are required for plant growth and metabolism. These are supplemented to soil either in the form of fertilizers or through manures and composts. The availability of both macro and micronutrients in the soil determines its fertility which therefore governs the crop productivity of that soil

(Bharti *et al.* 2017). Soil testing discovers the current fertility status of soil which provides information with respect to nutrient availability in soils and forms the basis for fertilizer recommendations to increase crop yields and to maintain optimum soil fertility **(Singh *et al*. 2018).** Obviously, soil fertility map provides accurate knowledge about fertility status of soil for a particular area which can prove highly beneficial in advising the farmers and manufacturers and also planners who are associated with fertilizer marketing and distribution in identifying the requirement of various essential fertilizers in a season or year and to make projections for enhanced requirement on the basis of cropping pattern and cropping intensity. Hence, Soil analysis and its interpretation is the best way to determine the status of available nutrients in agriculture systems because most of the people in India depends on agriculture.

Apart from the soil quality, sustainable agriculture requires the irrigation system with improved performance to provide good quality of food and energy for entire population. Water quality for agricultural purposes is evaluated based on the the effect of water on quality and yield of the crops and the effect on changes in soil characteristics **(FAO, 1985).** Irrigation water plays a vital role for crop cultivation. The quality of irrigation water should be within the permissible limit otherwise it could adversely affects the crop growth. Both the qualitative and quantitative characteristics of the groundwater have an equal importance in socio-economic development of any society **(Omran *et al.* 2014).** Water quality assessment is a process of determination of true nature of water by evaluating the presence of different parameters and their limits through various experiments available. Quality of irrigation water describes the amount of sediments suspended in it and chemical constituents present in the water. If the irrigation water quality is good, it extends the crop production under normal water management and soil practices. If irrigation water quality is poor, it reduces the soil permeability and in turn decreases the crop production due to non-availability of water **(Subba Rao 2017).** Hence, it is important to test the water quality as it plays a vital role in monitoring plant life and environment.The evaluation of water quality can be done through In-situ measurements and by examining the samples in laboratory. The general criteria for irrigation water includes salinity, sodicity or alkalinity and elemental toxicity.

Andhra Pradesh is endowed with a wide variety of soils which is ranging from less fertile coastal sands to highly fertile and also productive deltaic alluviums of major river basins (Godavari, Krishna and Penna) developed from different type of parent materials. There are 6 major soil groups that includes red soil belongs to the order alfisols occupying about 66%, black soils belongs to the order vertisols occupying about 25% and are formed from granites, gneisses and dharwars, alluvial soils belongs to the order entisols occupy 5% and are most fertile soils in the state, coastal sands belongs to the order entisols contributing about 3% , laterite and lateritic soils belongs to the order oxisols contributing about 1% of the state area.

Cuddapah is a district in Rayalseema region covering an area about 15,379 Sq. Kms and is divided into three Revenue Divisions namely Cuddapah, Rajampeta and Jammalmadugu. It was renamed as YSR District in the year 2010. To the north YSR district is encompassed by Kurnool District, on the south it is surrounded by Chittoor District, on the east it is surrounded by Nellore and on the west it is surrounded by Anantapur District and lies between 13°43' - 15°10' North latitude and 77°55' - 79°29' east longitude . Most of the people in this district depends on Agriculture for livelihood and major crops that are cultivating in the district are Paddy, sunflower, Groundnut, cotton and Horticultural crops are Banana, Mango, Papaya, Guava, Orange and Lemon.

The Gross cropped area of the district is 4,72,511 hectares from this 1,92,832 hectares is the gross irrigated area. There are two types of soils in the district viz., Red Ferruginous soils and Black soils. The most superior soil type found in the district is Black clay which covers 23.7% area in the district. The district is well known for its mineral wealth. The major minerals are Barytes deposits, deposits of clay, Limestone and Asbestos. Apart from this, Minor minerals like Napa slabs, Building stones, Marble, Road metals, Mosaic chips etc., are found in the district. The major rock types found are quartzites, shales, limestones, granodiorites, phyllites, granites and gneiss. These rock types are majorly observed in South west part of the district. The district consists 42.68% of Agricultural land from total geographical area and Forest area about 32.05% followed by waste lands which covers 17.14% , water bodies 5.83% and builtup areas 2.3%.

The irrigation projects occupying the district are Kurnool - Cuddapah canal at an extent of 92,001 acres ayacut, Tungabhadra project high level canal at an extent of 75,000 acres ayacut and Pulivendula branch canal to an extent of 55,239 acre ayacut and many other irrigation projects and construction of reservoirs are ongoing for distribution of water to many towns and villages.

By considering all these features an investigation was carried out to examine and determine the soil and water quality status of Cuddapah block in YSR district, Andhra Pradesh by using different principles and procedures with the following objectives:

1. To characterize the quality status of the soil and water collected from Cuddapah block of YSR district, Andhra Pradesh.

2. To ascertain the soil fertility status of Cuddapah block and preparation of nutrient wise map to identify the nutrient deficient areas.

3. To study the correlation matrix between the soil and water quality parameters of Cuddapah block.

REVIEW OF LITERATURE

Soil and Water are the two important components which plays an important role for plant growh, metabolism and crop production. These two are inter-related with each other i.e, change in one system causes change in other system. So, the management practices for improving crop production should be done according to the changes occurred in the system. Based on the available sources and the information gathered literature is reviewed under the following sections.

2.1 Physico-chemical properties of the soil

- Bulk density
- Particle density
- Porosity
- Water holding capacity
- Soil pH
- Electrical conductivity
- Organic carbon

2.2 Primary Macronutrients in soil

- Nitrogen
- Phosphorous
- Potassium

2.3 Secondary Macronutrients in soil

- Calcium
- Magnesium
- Sulphur

2.4 Micronutrients in soil

- Iron
- Copper
- Manganese
- Zinc

2.5 Chemical properties of water

- Water pH
- Electrical conductivity
- Alkalinity (Carbonates and Bicarbonates)
- Total hardness (Calcium and Magnesium)
- Chloride
- Sodium and Potassium

2.6 Irrigation water quality Parameters

- Sodium adsorption ratio
- Residual sodium percentage
- Soluble sodium percentage
- Permeability index
- Kelly's ratio

2.1 Physical and Chemical properties of soils (pH , EC, Bulk density, PD, WHC, Porosity and Organic carbon)

Debnath *et al.* (2012) studied the soil fertility status of Sikkim. This study was carried out to evaluate the soil physico-chemical properties and its relationship with WHC along altitudinal gradient of cultivated soils in East Sikkim. The organic carbon content in soil ranged from 1.23 to 3.35 % with mean value 2.29%. Bulk density ranged from 1.08 to 1.53 gm/cm^3 and Particle density ranged from 2.15 to 2.76 gm/cm^3. The water holding capacity ranges between 35-72.85% with mean value 53.43%. The results stated that 75% of the soil samples have medium to high water holding capacity while 25% falls under low category. There was a significant positive correlation between WHC and Organic carbon and negative correlation between WHC and Bulk density, WHC and Particle density.

Viji and Rajesh (2012) studied assessment of water holding capacity (WHC) of major soil series in Lalgudi, Trichy, India. Soil samples were collected from 5 various locations at a depths of 15 cm and 30 cm. The results showed that bulk density (BD) of soil samples at 15 cm depth was varied from 1.19-1.42 g/cm^3, particle density (PD) was varied from 1.46-1.79 g/cm^3, porosity was found between 17.98-22.16% and WHC varied from 30.69 to 20.88% while at 30 cm depth the BD of the soil samples was ranged from 1.41 g/cm^3, PD ranged between 1.45-1.74 g/cm^3, porosity varied from 15.92-19.60% and water holding capacity varied from 20.46-29.33%.

Wagh and Sayyed (2013) studied the status of macronutrients and micronutrients in soils of Panvel area, Maharashtra. The total of 10 soil samples were collected from different locations in Poyange village near Panvel in Nov.2006-2007. The results revealed that pH in the soil samples was found to be in the range of 5.63-6.82 indicating acidic nature, EC values was ranged from 0.13-0.27 µS/cm indicating the soils are in non-saline conditions and Organic carbon was ranged from 0.59-1.57% which were < 2% and therefore the soils are considered to be deficient in organic matter content.

Shivanna and Narendrappa (2014) investigated the soil samples of selected command areas in Tiptur Taluk of Karnataka. The collected variables were tested for Soil pH and EC. The results observed that the pH of soil samples varied between 7.07 - 7.87 which states they are in slightly alkaline in nature but are within limit 6.5 - 8.5 which is optimum for growing crops. And values EC were between 0.26 - 0.485 dS/m but were within desired limit of 0.8 dS/m indicating that soils were in low saline conditions.

Nath (2014) studied the soils of some selected Tea growing areas in Sivasagar District, Assam. Total 30 composite soil samples were collected randomly from the top soil with a depth of 0-20 cm from 10 Tea estates. The results showed that the total organic matter varied from 2.16-3.38% whereas WHC varied from 50.44 – 59.18%. The soil samples have medium WHC and higher organic matter content in the soil. The results stated that there was a significant positive relationship between Water holding capacity and organic matter.

Wani *et al*. (2014) studied the physico-chemical properties of soils in Gwalior in Madhya Pradesh. Total of 16 soil samples were collected from different locations in Gwalior city and results showed that pH was found to be in the range of 9.5-10.2 and all the soil samples were alkaline in nature.

Wankhade (2015) studied the physical and chemical parameters of soils in Yavatmal District, Maharashtra. In this study seven soil samples were collected in a depth of 5-20 cm from some farms of nearby villages in Digras region, Dist. Yavatmal. The results showed that the soil Bulk density was ranged from1.12 – 1.23 gm/cm^3, Porosity ranged from 52.7 -57.4% and Maximum water holding capacity was ranged from 55.6 – 71.3% .

Kadam *et al*. (2016) carried out a research on analysis of physico-chemical parameters in Deulgaon Raja region, Maharashtra by collecting 60 soil samples from different villages. The results showed that it was clay loam type of soil with pH value ranging from 5.20 to 6.8 and recorded 1.37% of soil samples were in acidic condition and 92.64% are in normal range. The EC value of the soil samples was ranged from 0.30-0.46 dSm^{-1} whereas organic carbon content was recorded as very high which varied from 2.15-3.66%.

Tanveera *et al*. (2016) studied about soil bulk density in relation to texture, organic matter content and porosity in kandi soils of Kashmir valley. Total of 25 surface soil samples were collected from various locations at a depth of 20-35 cm. The results showed that Bulk density of soil samples varied from 1.12-1.46 gm/cm^3 and porosity was ranged from 32.86-57.36% . A significant negative correlation (r = -0.67) was observed between porosity and bulk density of the soil samples and a strong negative correlation (r = -0.75) was found between OM and BD.

Madhavi *et al*. (2018) studied about soil quality assessment under Rice cropping systems in Vishakapatnam District, Andhra Pradesh by collecting soil samples during three cropping periods i.e, before cropping period, middle of the cropping and after the cropping periods in Yelamanchili Mandal. The results were revealed that pH of the soil samples was varied between 7.4-7.8 indicating slightly towards alkaline and highest pH was observed at F2 sample 7.84 after cropping period while lowest pH was found at F3 sample before cropping period. Organic carbon (OC) was ranged from 0.78% to 0.95% with an average value of 0.87% in the soil samples for all three cropping periods where lowest value (0.72%) was noticed after cropping period and highest was observed in F2 sample (0.98%) during Middle of the cropping period.

Malavath and Mani (2018) studied the available nutrient status in different soils of semi arid regions in Tamil Nadu. Thirteen representative geo-referenced pedons were selected based on morphological characteristics and elevation of land and also horizon wise samples were collected . The results showed wide variation in organic carbon content which was varied from low to medium range (2.8 – 6.5 g/kg) in surface horizons while in subsurface horizons it was ranged from 0.70-5.0 g/kg which noticed low.

Naik *et al*. (2018) studied the soils of Vishakapatnam district, Andhra Pradesh using Geospatial techniques by collecting 82 soil samples randomly at different land use systems at a depth of 0-30 cm. The results showed that the pH of soil varies from 4.8-7.5 and 83% of study area showing acidic nature and EC varies from 0.04 - 0.87 ds/m with a mean of 0.21 dS/m which indicates Non-saline conditions.

Narsaiah *et al*. (2018) studied the Physico-chemical properties of Mulugu division in Warangal district, Telangana by collecting soil samples from 6 typical pedons. The results showed that Bulk density of various pedons ranged from 1.38-1.78 Mg/m^3 whereas Particle density of various pedons ranged from 2.55-2.65 Mg/m^3.

Barooah *et al.* (2020) studied about assessment of soil fertility status of 5 different villages in Lahowal block of Dibrugarh district in Assam by collecting 100 soil samples at 0-15 cm depth. The results was observed that pH of the soil samples were ranged from 4.30 to 6.30 with a mean value of 5.14 which shows all the soil samples were in acidic nature , EC values varied from 0.01-0.31 dSm^{-1} with a mean value of 0.06 dSm^{-1} and organic carbon content was varied from 0.33-1.20% with an average value of 0.75%.

2.2 Primary Macro-nutrients in soil (Nitrogen, Phosphorous and Potassium)

Verma *et al*. (2005) studied macronutrients in soils of arid tract of Mansa district, Punjab. In this study surface soil samples were collected from 208 sites. The results in the study revealed that the organic carbon content present in the soils are low and ranged from 0.02-0.40% and available phosphorous content of these soils ranged from 1.8 -59.6 kg/ha. And the results concluded that the fertility status of soils on various land forms noticed to be low in available Nitrogen and low to high in available phosphorous content .

Sharma *et al.* (2008) studied the mapping of Nitrogen, Phosphorous and Potassium in soils of Amritsar, Punjab, India. Geo-referenced surface soil samples were collected randomly at flag leaf stage of Wheat at a depth of 0-0.15 m from 645 different sites. The results were revealed that available N was ranged from 63-170 kg/ha, available P content ranged from 9.4-84.9 kg/ha and available K was ranged from 84-700 kg/ha.

Vijayakumar *et al.* (2011) studied about nutrient status of soils in Tsunami affected areas of Srikali taluk in Tamil Nadu by collecting 100 surface soil samples from 18 different villages and analyzed for various parameters using standard methods. The results stated that available N was varied from 124.49-397.67 kg/ha with a mean value of 187.7 kg/ha , available P ranged from 3.705 – 17.29 kg/ha with an average value of 11.36 kg/ha and status of available K varied from 135.85-432.25 kg/ha with a mean value of 237.37 kg/ha.

Pujar *et al.* (2012) studied the physico-chemical parameters in soils of Bijapur Taluka, Karnataka by collecting top soil samples at a depth of 0-10 cm from various locations. The results were revealed that the available nitrogen content was in lowest range i.e, 135-160 kg/ha and might be due to mineralization because of high temperature and loss of Nitrogen in the form of ammonia because the soils are calcareous. The available phosphorous was varied from 8.0 to 10.1 kg/ha indicating low in range. And potassium content was varied from 295 to 355 kg/ha which was high in range.

Chaudhari *et al.* (2013) studied the Soil Bulk density as related to texture, organic matter and available nutrients in soils of Coimbatore. The Bulk Density of soil ranged from 1.25-1.57gm/cc and organic carbon content ranged from 0.13 - 0.78%, available N ranged from 88-138 kg/ha, available P from 6.38 – 68.47 kg/ha, available K from 123-964 kg/ha. The results stated that Soil bulk density showed negative relationship with OC, available N, P, and K.

Awinash Kumar *et al.* (2014) studied the soil fertility status of Kabeerdham District, Chattisgarh. In this present study surface soil samples were collected at a depth of 0-15 cm from 4 blocks, 84 selected villages in Kabeerdham District from vertisol. The results stated that the available Nitrogen content in the soil samples ranged from 100-304 kg/ha, available Phosphorous ranged from 2.06-20.88 kg/ha and available potassium ranged from 208-821 kg/ha.

Nagaraja *et al.* (2014) studied soils of Chitradurga District, Karnataka. In this study soil samples were collected randomly at a depth 0-15 cm in all taluks of Chiradurga district and analyzed for their physico-chemical properties. The results showed that available nitrogen content in the samples were varied from 250-439 kg/ha with an average value of 337 kg/ha and considered to be medium in all soil samples, available phosphorous content varied from 65-337 kg/ha with a mean value of 163 kg/ha and found to be high in all the soil samples and available potassium was varied from 56-351 kg/ha indicating high in all soil samples except in S5 and S17. As per the data it is concluded that all the soil samples were in permissible limits and therefore the soil considered to be suitable for both agricultural and horticultural crops.

Ravikumar and Somashekar (2014) studied the Spatial distribution of macronutrient status in soils of Markandeya river basin, Belgaum district, Karnataka. The soil samples were collected from 30 different agricultural fields in the study area. The results showed that available N content in the soils ranged from 29.1 -189.5 kg/ha, 50 % of soil samples have shown low to medium available P i.e, 0.96-15.1 kg/ha and 90% of samples have available K in adequate amounts ranged from 313.3-1500.8 kg/ha.

Shivanna and Nagendrappa (2014) evaluated the soils of Tiptur taluk in Karnataka. The resulted data showed that available Nitrogen values are lied between 54.82-85.72 kg/ha, available Phosphorus values are lied between 5.33-10.79 kg/ha which indicates that the soil samples are deficient in Nitrogen and Phosphorous.

Jain *et al*. (2014) studied the soil nutrient status of Lunawada Taluk, Gujarat by collecting soil samples from 10 different villages . The resulted data stated that available N in the soil was found between 0.03-0.07%, available P varied between 12-100 kg/ha and available K varied from 132-914 kg/ha.

Chandak *et al*. (2017) studied the soils of Kadi city in Gujarat. In this study soil samples were drawn from four different villages (5 samples from each village) and analysed various physical and chemical properties. The obtained results revealed that Phosphorous was value found between 7.77 -23.31 kg/ha while values of potassium ranged between 188.48 – 243.04 kg/ha.

Srinivasan *et al.* (2017) conducted a study to assess the nutrient status and soil properties of three different land use systems of Horticulture crops (Cashew, Mango and Arecanut) in Coastal Odisha. The results stated that available N in the surface layer was ranged from 85-259 kg/ha while in subsurface soils ranged from 40-221 kg/ha. The greatest Phosphorous content was observed in surface layer of arecanut i.e, 10.7-57.1 kg/ha and lowest was 3.7 kg/ha found in Cashew. And available K content in the surface soil was varied from 57-438 kg/ha and in subsurface soil was ranged from 14-553 kg/ha (categorized as low in range).

2.3 Secondary Macronutrients in soil (Calcium, Magnesium and Sulphur)

Sharma *et al.* (2008) studied the spatial distribution of Macronutrients in soils of Amritsar district, Punjab. A random geo-referenced surface soil samples were collected (0-0.15 m depth) at flag leaf stage of Wheat from 645 different sites by using GPS. The results showed that available sulphur content in the soil samples was varied from 24.6 to 60.0 kg/ha.

Pulakeshi *et al.* (2012) conducted a study to analyze available nutrients in soils of Mantagani village in Northern Karnataka by using GIS technique. Total 115 soil samples were collected from the farmers fields at a depth of 0-30 cm and analyzed for their fertility status. The results were revealed that available sulphur content in red soils was ranged from 9.5 – 12.1 kg/ha whereas in black soils it was ranged between 17.4-34.7 kg/ha and noticed available sulphur in the soils was low to medium range.

Singh *et al.* (2017) studied about physical and chemical characteristics of soils of Lahar block, Bhind district, Madhya Pradesh. In this study total of 10 surface soil samples were taken from farmer's field at 0-15 cm depth. The results were showed that Calcium (Ca^{2+}) content in the collected soil samples was varied between 4.50-9.05, Magnesium (Mg^{2+}) content was varied from 2.73-6.99 and available Sulphur content present in the soil samples was ranged between 16.58-26.68 . As per the obtained results it was found that Ca^{2+} and Mg^{2+} content in the soil samples was 100% sufficient whereas available Sulphur content was medium in 40% samples and high in 60% of the soil samples.

Sudheer *et al*. (2017) studied the fertility status in soils of Mid Himalayan region in Himachal Pradesh. The results revealed that Sulphur content in the soil was ranged from 14.0-32.0 kg/ha with 23.77 kg/ha mean value and stated 20% of the soils exhibit deficiency symptoms.

Barooah *et al.* (2020) studied the assessment of soil fertility parameters in Lahowal Block, Dibruggarh, India. Total 100 soil samples were collected at 0-15 cm from five villages and analyzed for various physical and chemical parameters. The results were revealed that available sulphur content in the soil samplers was ranged from 6.43-23.87 mg/kg with an average value of 14.33 mg/kg and found 63% samples were in medium range while 17% samples were in sufficient range . This low to medium range amount of sulphur content in the soil is due to lack of application of sulphur fertilizers and sulphur removal by crops and Intensive cropping without sulphur fertilization may cause depletion of sulphur in soil.

2.4 Available Micronutrients in soil (Iron, Copper, Manganese and Zinc)

Wagh and Sayyed (2013) studied the Nutrient status of soils in Panvel, Maharashtra. Soil samples were collected from 10 representative locations and analyzed for various soil fertility parameters. The results revealed that Cu concentration in the soils was in the range of 8.04-10 ppm indicating Cu enrichment, Fe content has been found in the range of 17.54-26.04 ppm representing very high than normal range, Similarly, the soils are highly enriched in Mn concentration ranged from 15.76-18.74 ppm and also enriched in Zn content ranged between 0.56-1.60 ppm.

Subramanian *et al.* (2014) studied the soil nutrient status of Salem in Tamil Nadu by collecting 348 soil samples from small, medium and large farmers. Soil samples were drawn at 0-15 cm depth from eight different villages and the results showed that Zinc content ranged between 0.01-8.77 mg/kg indicated all the samples were found to be Zn deficient. Iron content was found to be in the range of 0.42-44.0 mg/kg which indicates Fe content was in sufficient range in all the soil samples, Cu content was ranged from 0.04-8.14 mg/kg and Mn content was ranged between 0.50-75.2 mg/kg indicated sufficient range in all the samples.

Basavaraja *et al*. (2015) studied the soil fertility status of Hassan district, Karnataka. About 1320 soil samples were collected from eight taluks in Hassan district at 0-15 cm depth by using GPS. The resulted data noticed that Zn was ranged from 0.08-6.70 mg/kg and 79.33% of soil samples were exhibited Zinc deficiency. Fe content varied between 0.77-82.53 mg/kg, most of the soils are enriched with iron content.

Kavitha *et al.* (2015) studied the soil fertility status of Trissur district by collecting soil samples under 8 different agro ecosystems. The results were showed that Zn concentration in the soil samples were ranged from 0.01 -100.2 ppm, Boran concentration ranged from 0.001-1.23 ppm, Cu contentration varied between 0.01-54.1 ppm , Fe concentration lied between 0.1-675.4 ppm and Mn concentration was lied between 0.1-280.2 ppm and concluded that all the micronutrients were founded to be high in range except boron.

Yurembam *et al.* (2015) studied the soil fertility status of Someshwar watershed, Uttarkhand by collecting samples from two different soil depths i.e, 0-15 cm and 15-30 cm. The resulted data stated that Fe content of the soil samples was ranged from 30-83.7 mg/kg, Mn content ranged between 1.2-5.9 mg/kg while Zn content was found between 0.10-1.29 mg/kg and Cu content of the soil samples was varied from 0.12-4.52 mg/kg.

Srinivasan *et al.* (2017) studied the soils of Coastal Odisha under three horticultutal land use systems. The results revealed that Fe and Mn content (> 4.5 and >2.0 mg/kg) were sufficient in all land use. The available Cu content was rich (1.76-3.57 mg/kg) in surface soils of arecanut whereas Zn content ranged from 0.68 - 1.68 mg/kg in surface and subsurface layers of soils.

Srivastava *et al.* (2017) studied the analysis of micronutrient status as related to characteristics of soil by collecting soil samples under Tasar growing areas of Bihar and Jharkhand. The results showed that concentration of Zn ranged from 0.83-8.58 mg/kg with 2.29 mg/kg mean value, concentration of Fe was ranged from 3.25-35.72 with a mean value of 15.93 mg/kg, concentration of Mn in the soil samples ranged from 5.7-85.9 mg/kg with 42.81 mg/kg mean value and concentration of Cu varied from 0.23-0.84 mg/kg with an average value 0.74 mg/kg.

Vineet kumar *et al.* (2018) studied the availability of macro and micronutrients in relation to some physico-chemical properties of soil in Udham Singh Naagar , Uttarkhand. The results showed that values of DTPA extractable Fe was ranged between 12.42-54.06 ppm, Mn ranged from 0.96-22.06 ppm, Zn ranged from 0.26-4.64 ppm and Cu ranged from 0.59-7.62 ppm and these micronutrients were non-significantly and positively correlated with soil pH and Organic Carbon.

Vikas Umare (2018) studied the soils of Chandrapur in Maharashtra by collecting soil samples and determined various physico-chemical parameters. The results showed that Manganese (Mn) was ranged from 2.32-3.02 ppm, Zinc (Zn) was ranged from 0.42-0.68 ppm and found to be deficient except in S4 sample, Copper (Cu) was varied from 0.45-0.84 ppm which meets the requirement for proper plant growth and Iron (Fe) ranged from 3.24-4.68 ppm which is noticed as severe deficient of Iron content in all the soil samples except in S7 sample which lies just near margin to reference range and may be due to low OM and sandy soil texture.

2.5 Chemical properties of water

pH and Electrical Conductivity

Janardhana Raju (2007) studied the analysis of ground water quality in upper Gunjanaeru River basin situated in Cuddapah district, Andhra Pradesh by collecting 51 water samples in post –monsoon and 46 water samples in pre- monsoon seasons and analyzed for various quality parameters. The results showed that values of Electrical Conductivity (EC) was ranged from 150-1850 µmhos/cm at 25°C with an average value of 752 µmhos/cm during post-monsoon season while in pre-monsoon EC values ranged between 140-1515 µmhos/cm at 25°C with an average value of 550 µmhos/cm at 25°C in post-monsoon season.

Jothivenkatachalam *et al*. (2010) studied on correlation of drinking water quality of Coimbatore district, Tamil Nadu and analyzed for various quality parameters. The results were revealed that pH of the water samples was found to be in the range of 6.6-7.9 which is within the permissible limit prescribed by WHO. And EC values ranged from 1020-2910 µmhos/cm.

Usharani *et al*. (2010) studied different water quality parameters of Noyyal river and Groundwater of Perur, India. The results showed that pH value of river water ranged from 7.81-8.11 with a mean value of 7.99 while pH value for groundwater ranged from 7.27-7.78 with a mean value of 7.47. EC values of river water varied from 0.54-0.61 µmhos/cm with a mean value of 0.57 µmhos/cm whereas in groundwater EC ranged from 1.1-1.34 µmhos/cm with a mean value of 1.22 µmhos/cm.

Prasanth *et al.* (2012) studied the groundwater quality assessment in coastal belt of Alappuzha District in Kerala. The hydro-geochemical study was carried out to assess the quality of ground water by examining various physico-chemical parameters. The results were revealed the pH value of most of the water samples was ranged from 5.2 to 6.8 which indicates the ground water is slightly acidic in nature whereas value of EC was found in the range of 64.02 -2199.57 µmhos/cm with a mean value of 514 µmhos/cm which indicates higher amount of salts are present in the groundwater and TDS value was varied between 94.1-1898.21 mg/l.

Gummadi *et al.* (2015) studied the irrigation water quality by collecting water samples from borewells, open wells and canals in Coastal Andhra Pradesh regarding monthly wise during 2009-2010. The results were revealed that pH of most of the samples were found within lower limit i.e, ranged from 7.54-8.52 whereas electrical conductivity (EC) value of the samples varied between 453.24-658.4 µmhos/cm.

Appavu *et al*. (2016) studied physico-chemical parameters of water by collecting samples from Cauvery river in Erode District. The results showed that pH value of water samples varied between 7.63-7.86. EC values were recorded as low at North 564 µS/cm , in west 920 µS/cm , in south 653 µS/cm and in east about 692 µS/cm.

Devojee *et al.* (2018) studied the assessment of irrigation water quality by collecting water samples from 26 villages in Bapatla region , Guntur, India. In this study irrigation water samples were collected from bore wells manually and analyzed for different quality parameters. The results stated that EC of the water samples was ranged from 300-1000 mg/l for most of the villages and TDS (Total dissolved solids) was ranged between 420-709 mg.

Anions (Cl^- , CO_3^{2-}, HCO_3^-)

Yogendra and Puttaiah (2008) studied the determination of Water Quality Index (WQI) of an urban water body in Shimoga, Karnataka. The study was carried out to ascertain the water quality for drinking, irrigation and industrial purpose. The results showed that chloride content was varied between 156-178 mg/l and found to be high during summer and low during rainy season. And Total alkalinity was ranged from 58-78 mg/l.

Rima Chatterjee *et al*. (2010) studied the assessment of Dhanbad district, Jharkhand. Groundwater samples were collected from coal mining area to study the spatial variation of groundwater quality based on analysis of physico-chemical parameters using GIS. The results were revealed that Bicarbonate concentrations (HCO_3^-) was ranged from 33-475 mg/l with an average 50% of total anions in subsurface water whereas chloride (Cl^-) ions varied from 9.7-245 mg/l in the subsurface water which result due to pollution by sewage waste and anthropogenic activities or leaching of saline residues in soil.

Saravana kumar and Ranjith kumar (2011) studied about groundwater quality parameters near Ambattur Industrial area, Tamil Nadu. The results were showed that chloride ion concentration present in the water samples was observed in the range of 325-380 mg/l and lies within the permissible limit (500 mg/l) prescribed by WHO.

Lokhande *et al.* (2011) studied the Physico-chemical analysis of waste water effluents in Tajola Industrial area of Mumbai. The results in the study revealed that chloride content in the effluents collected from textile industries was 238.4 mg/l which was significantly higher than the permissible limit of 200 mg/l prescribed by WHO.

Magesh *et al.* (2012) studied about groundwater quality status of Dindigul district, Tamil Nadu. Total of 59 groundwater samples were collected from borewells by using GIS and analyzed for various physico-chemical parameters. The results revealed that bicarbonate concentrations were ranged from 29.48-732 mg/l.

Selvakumar *et al.* (2014) studied Groundwater quality status in Tiruchirapalli district, Tamil Nadu. In this study total 20 groundwater samples were collected from dug wells and borewells of South Tiruchirappalli and analyzed for different hydrogeochemical parameters. The results were stated that Bicarbonate concentrations ranged from 93-298 mg/l with a mean value of 192.2 mg/l and chloride concentration varied from 26-1010 mg/l with a mean value of 222.8 mg/l.

Cations(Na^+,K^+ ,Ca^{2+} ,Mg^{2+})

Subbarao (2005) studied about seasonal variation of ground water quality in Guntur District, Andhra Pradesh. In this study ground water samples were collected seasonally i.e, pre-monsoon and post-monsoon for three years from 40 wells and analyzed for Physico-chemical parameters. The results were stated that during pre-monsoon , Calcium was varied from 30-90 mg/l and Magnesium was varied from 26-145 mg/l whereas in post-monsoon , Calcium was ranged between 24-100 mg/l and Magnesium ranged between 35-180 mg/l.

Kumar Yadav *et al.* (2012) studied the analysis of physicochemical parameters of ground water samples in Agra, Uttarpradesh. The study was carried out by collecting water samples from 12 different sites from Feb. to May. The results revealed that Calcium content was ranged from 72-436 mg/l , Magnesium ranged between 14.6-151.2 mg/l and concluded that all the water samples do not comply with standards prescribed by WHO and ISI -10500-91 , so that water is not considered as good quality for drinking purpose.

Magesh *et al.* (2012) studied the assessment of groundwater quality using GIS and WQI techniques in Dindigul district of Tamil Nadu. Total 59 water samples were collected from borewells and analyzed for their physico-chemical parameters. The results were showed the concentration of Sodium ions in groundwater samples was ranged from 5-478 mg/l , Potassium was ranged from 0.1-203 mg/l, Calcium concentration varied from 20-480 mg/l and Magnesium concentration was ranged from 3.64-354.78 mg/l.

Selvakumar *et al.* (2014) studied the analysis of groundwater quality for various hydrogeochemical parameters in Tirchirappalli district, Tamil Nadu by collecting 20 groundwater samples from dug wells and bore wells of Southern Tiruchirappalli. The results were revealed that Sodium (Na^+) concentration varied from 12-221 mg/l with an average value 112.9 mg/l which exceeds the desirable limit prescribed by WHO i.e, 200 mg/l. The potassium ion (K^+) concentration was ranged between 9-90 mg/l with a mean of 40.1 mg/l and its high concentration is due to the fertilizer effect and due to industrial activities located nearby sites.

Qureshimatva U.M. *et al.* (2015) carried out a research to determine various Physical and chemical parameters and Water quality index (WQI) in Chandlodia lake, Ahmedabad, Gujarat. The results were revealed that calcium content in the water samples was ranged from 72-94 mg/l, highest amount of calcium was noticed during monsoon and lowest value was recorded in summer season. Magnesium content was ranged from 36-41 mg/l where highest value was recorded in monsoon and lowest value was recorded in summer season.

Saxena and Sharma (2017) studied about evaluation of WQI for drinking purpose by collecting water samples at 5 different sites in and around areas of Tekanpur, Madhya Pradesh. The results revealed that Ca^{2+} concentration was found to be in the range of 27.25-96.16 mg/l and calcium hardness was found in GW2 and GW3 are reaching towards upper limit (100 mg/l prescribed by WHO) and this may be due to underground water beds and weathering of limestone in the catchments. Mg^{2+} concentration ranged between 20.95 – 51.68 mg/l except for GW3 and GW5 samples.

Aravinthasamy *et al.* (2020) conducted a study to determine the suitability of groundwater for irrigation purpose by using irrigation water quality index with the application of geographical information system (GIS) by collecting 61 groundwater samples and analyzed for different chemical parameters. The results were showed that Sodium (Na) was ranged from 22-350 mg/l and Potassium was ranged from 5-60mg/l.

2.6 Irrigation water Quality Parameters (SAR, RSC, SSP, PI, KR)

Joshi *et al.* (2009) analyzed the irrigation water quality of Ganga River in Haridwar, Uttarakhand. In this study, total 90 water samples were collected from five sampling stations by dividing the study into three seasons i.e, winter , summer and rainy season. Water quality variables have been measured inside the river over a period of 2 years (Nov.2006 to Oct.2008). The results revealed that RSC value of all the sampling stations are below 1.25 meq/lit and concluded that water of Ganga river is safe for irrigation purpose according to the values given by U.S. Salinity Laboratory.

Vasanthavigar *et al*. (2010) studied the application of water quality index for ground water quality assessment in Thirumanimuttar sub-basin, Tamilnadu. This study was carried out to understand hydrogeochemical parameters to develop water quality in sub-basin of Thirumanimuttar by collecting 148 groundwater samples and analyzed different parameters. The results revealed that during pre-monsoon, SAR values were found between 1-44meq/l and considered that 85% of water samples are unsuitable for irrigation purposes. During post monsoon SAR values ranged from <0.5 to 37meq/l and 48.56% of the samples are considered to be unsuitable for irrigation purposes. RSC values during pre-monsoon was observed from 12.2-11.73 meq/l indicating 75% of the total samples were in permissible limit whereas in post monsoon RSC values are found between 28.67-15.56 meq/l .

Kumaraswamy *et al.* (2013) analyzed the quality of irrigation water in Tamirapani river in Southern India. In this study water samples were collected from different regions and analyzed physical and chemical parameters. The results were revealed that Sodium Adsorption Ratio (SAR) was ranged between 0.14 – 9.23

meq/lit , Residual Sodium Carbonate (RSC) was ranged from 0.32 - 5.64 meq/lit whereas Permeability Index (PI) ranged from 12.5-89.7 meq/lit.

Haritash *et al.* (2016) analyzed the water quality status of Ganga river, Rishikesh during Dec.2008 by collecting water samples. The study was carried out to assess the suitability of water in Ganga river for drinking purpose, irrigation and other industrial use by using various indices. The results showed that calculated values of SAR was ranged from 0.24-0.43, RSC was ranged from4.9-34.2 , SSP was varied from 9.71-25.54 with an average value of 19.24 and Kelly's ratio was found to be in the range of 0.1-0.34 with an average value of 0.243. As per the resulted data it is concluded that the water in Ganga river was excellent for the use of irrigation for long time period.

Aravinthasamy *et al.* (2020) studied groundwater quality for irrigation water quality by using IWQI with the application of GIS. In this study total 61 groundwater samples were collected and analyzed for various chemical parameters. The results were revealed that calculated values of Kelly's ratio (KR) are varied from 0.29-1.68 and considered 79% of the groundwater samples are suitable for irrigation purpose while 21% of the samples are unsuitable for irrigation use.

MATERIALS AND METHODS

The present chapter dealt with materials and methods which are followed during research work in the evaluation of physical and chemical properties of soil and water that are collected from Cuddapah block in Andhra Pradesh. The information on the collected area, data regarding the soil and water, the procedures and techniques that followed during research had been described in brief under different sections and sub-sections.

3.1 Reagents and instruments used for soil analysis and water analysis

Table 3.1a: Reagents and solutions used for soil analysis

ANALYSIS	REAGENTS USED
Soil nitrogen	• 2.5% of sodium hydroxide • Mixed indicator(0.1 of bromocrosol green and 100ml ethanol) • 2.5% of boric acid • 0.32% of potassium chromate
Soil phosphorous	**BASIC MEDIUM** • O.5N sodium bicarbonate solution • Dacro-g-60 or charcoal • Ammonium molybdate solution • Ascorbic acid • Antimony potassium tartrate solution • 2.5M sulphuric acid • P-nitro phenol indicator
Soil potassium	• Standard potassium chloride solutions • 1N Ammonium acetate solution

ANALYSIS	REAGENTS USED
Soil pH	• Buffer solutions of 4.0, 7.0 and 9.2 • Soil and distilled water suspension in the ratio of 1:2.5
Soil electrical conductivity	• Soil and distilled water suspension in the ratio of 1:2.5
Soil organic carbon Walkey and Black rapid titration method	• 1N potassium dichromate • 0.5N ferrous ammonium sulphate • Diphenylamine indicator • Concentrated H_2SO_4 (sp.gr.1.84) • Orthophosphoric acid or sodium fluoride
Soil calcium and magnesium	• Ammonium acetate solution • Aqua regia(HCL + HNO3) • Erichrome black-T indicator • EDTA(ethylene diamine tetra acetic acid) • Muroxide indicator • 4N NaOH buffer solution • Ammonium chloride – ammonium hydroxide buffer solution
Soil sulphur	• 0.15% of calcium chloride • Barium chloride crystals • 0.25% of gum acacia • Standard potassium sulphate solutions
Available Micronutrients (Lindsay and Norvell, 1978)	• 0.005 M DTPA (Diethyline Triamine Penta Acetic Acid), • 0.01M calcium chloride dehydrate and • 0.1M triethanol amine buffered at pH 7.3.

Table 3.1b: Reagents and solutions used for water analysis

ANALYSIS	REAGENTS USED
Water pH	• Buffer solution of pH 4.0, 7.0 and 9.2
Water electrical conductivity	• 0.01N KCL solution
Calcium and magnesium	• 0.01N EDTA solution • Muroxide indicator • Sodium diethyl dithio carbamate crystals • 4N NaOH buffer solution • Erichrome black-T indicator • Ammonium chloride-ammonium hydroxide buffer
Chloride	• 0.02N silver nitrate solution • 0.02N sodium chloride solution • Potassium chromate indicator
Carbonates and bicarbonates	• 0.05N standard sulphuric acid • Methyl red indicator • Phenolphthalein indicator
Sulphate	• 0.15% of calcium chloride • Barium chloride crystals • 0.25% of gum acacia • Standard potassium sulphate solutions
Potassium	• Standard potassium chloride solution
Sodium	• Standard sodium chloride solution

Table 3.1c: Instruments and apparatus used for soil and water analysis

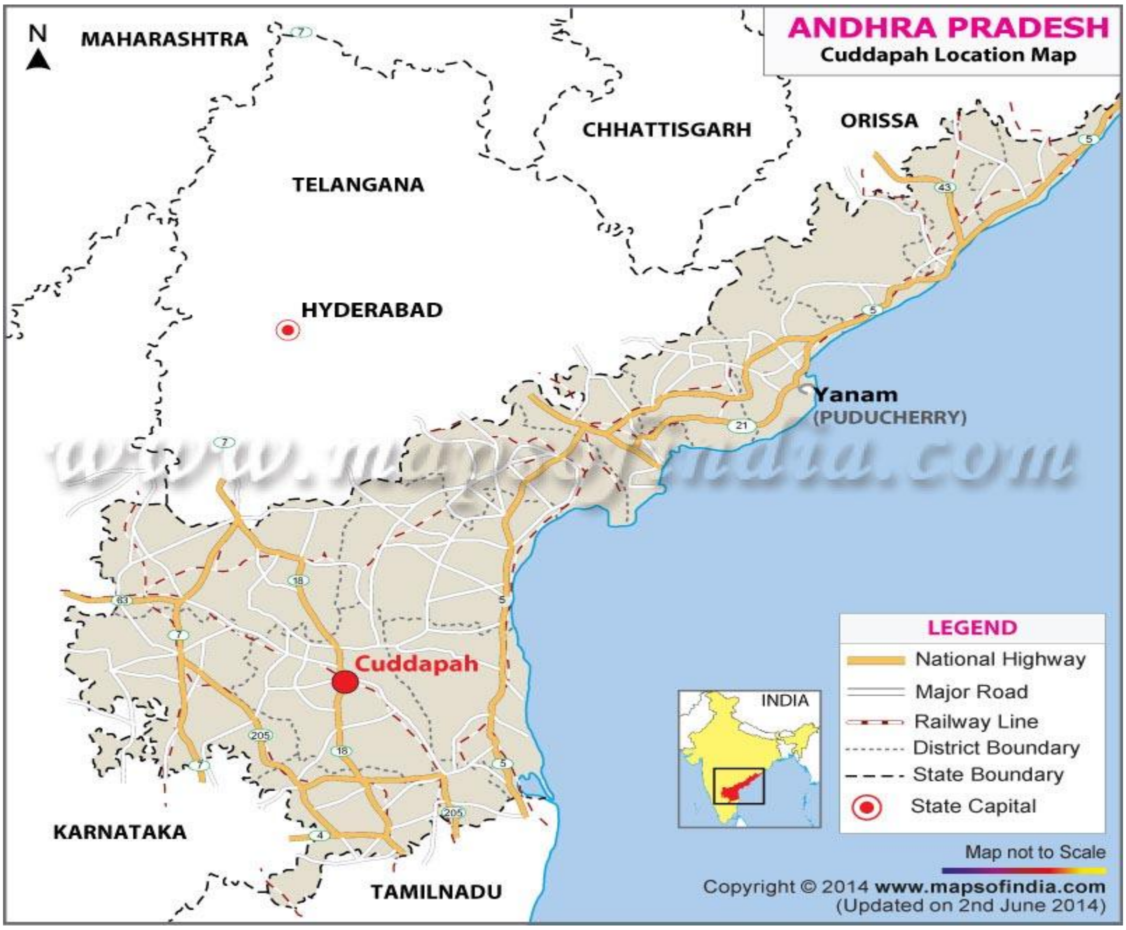
INSTRUMENTS	USES
pH meter	For measuring soil and water pH
Electrical Conductivity meter	For measuring salinity in soil and total dissolved salts(TDS) in water
Hot air oven	For drying the soil samples for 24hrs @105˚C
Flame photometer	For measuring the soil and water potassium, sodium & calcium content
Spectrophotometer	For measuring phosphorus content in soil
Shaker	For uniform mixing
Weighing balance	To measure the chemicals in grams or kilograms
Semi-Auto Nitrogen analyser	For estimation of available nitrogen in soil
Atomic Absorption Spectrophotometer	For estimation of available micronutrients in soil (Fe, Mn, Zn and Cu)

3.2 Description of site

3.2.1 Location

Cuddapah is a mandal located in the Rayalseema region of the south-central part of Andhra Pradesh in India. It is the district headquartes of YSR district and administered under Cuddapah revenue division. This city is surrounded on three sides by Nallamala and Palkonda Hills which are lying on the tectonic landscape between the Eastern and Western ghats.

Figure 3.2.1a: Location map of Cuddapah block



3.2.2 Geography

Cuddapah is located at 14.47°N and 78.82°E with an average elevation of 138 mts i.e, 453 ft above the mean sea level. Cuddapah has a semi arid climate and is characterized by year round high temperatures. During summers the average temperature ranges from 24°C - 43°C and occasionally the temperature reaches more than 46°C. During winters, the temperature is lower after the onset of monsoons and the average temperature ranges between 25°C - 35°C.

Table 3.2.2a: Meteorological data of Cuddapah block

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average high temperature in °C	32.1	35.3	38.8	40.8	40.5	37.1	34.8	33.7	33.8	32.7	31.2	30.6
Average low temperature in °C	18.9	20.9	24.2	27.1	27.8	26.7	25.6	25.1	24.7	23.8	21.1	18.9
Average rainfall in mm	2.6	0.8	6.6	16.5	51.6	76.9	122.7	119	152.	139.5	60	18.1
Average Relative Humidity(%)	50	39	31	30	34	46	52	56	58	63	65	60

(Source: Wikipedia.org)

3.2.3 Soils and agriculture

The soils in Cuddapah are of two types ie., Red Ferruginous and Black Soils. The most superior soil found is Black Clay, which occupies 23.7% area in the district. It is rich in mineral value. Barytes, Limestone and Asbestos are the major minerals in Cuddapah. And the minor minerals are Napa Slabs, Road Metal, Building stone, Marble, Mosaic chips etc., The majority of the people in Cuddapah depends on Agriculture for livelihood. the major Agricultural crops grown are Paddy, Groundnut, Sunflower, Cotton, Betel leaves and Horticulture crops like Mango, Papaya, Lemon and Oranges.

3.3 Method of Soil Sampling

Forty soil samples were collected from 10 different villages or sites of Cuddapah block, YSR district, Andhra Pradesh. Firstly, leaf litter, small twigs and stones were removed from the soil surface of sampling site and by using spade the soil was digged upto 15 cm depth in V shape so that all the soil horizons are shown up. In the form of zigzag manner 5-7 representative samples were collected from each field. The collected soil samples are of 2 cm thickness, 3-5 cm width and 15 cm depth. About 3 kg of soil sample was collected approximately spread on the large cloth and mixed in order to make soil homogenous once the mixing was done left over root twigs, leaves were removed and the sample was reduced to 1 kg by quadratic method. Then the soil was packed in polythene bags and sample number, sample location and date of sampling were noted on the bags and brought to the laboratory. In laboratory the composite soil samples were shade dried and crushed manually with pestle and mortar and sieved by passing through 2 mm size sieve mesh. About 500 g of soil sample have been taken after sieving and thus obtained soil sample was stored in a clean polythene bag. In this study 10 different villages were selected for the collection soil and water samples where land types were cultivated and fallow lands and total 40 soil samples were collected and analyzed for major physical and chemical properties by adopting standard laboratory methods at Rajiv Gandhi South Campus, Banaras Hindu University, Mirzapur, Uttar Pradesh.

Description of soil sampling sites is presented in Appendix-1

3.4 Physical and chemical analysis of soil samples

The collected soil samples were analysed for different physical and chemical parameters in the laboratory. The physical parameters include bulk density, particle density, porosity and water holding capacity while chemical parameters include pH, electrical conductivity (EC), organic carbon (OC), primary macronutrients (Nitrogen, Phosphorous, Potassium), secondary macronutrients (Calcium, Magnesium, Sulphur) and Micronutrients (Iron, Manganese, Zinc and Copper).

3.4.1 Determination of Bulk Density

The bulk density of the soil can be determined in two common methods. One is Pycnometer method for disturbed soils and another one is Core sampler method for undisturbed soils. As the collected soil sample is disturbed, soil bulk density was estimated through pycnometer method given by **Black (1965).** At first empty pycnometer which is dry and clean was taken and weighed in electrical weighing balance (W1) and the value was noted. Now filled the soil upto the brim in the same pycnometer by tapping gently and taken weight of it (W2). Then the soil was removed from the pycnometer . Now Burette was taken and filled the water in it , then dropped water into the pycnometer and noted down the burette reading (v). Here Burette was used to get actual volume of the pycnometer. to get actual volume of the pycnometer. To get Bulk density of soil, the recorded values are applied in the following formula.

$$\text{Bulk density} = \frac{w2 - w1}{v}$$

3.4.2 Determination of Particle Density

The particle density of the soil was estimated by Pycnometer **(Black ,1965).** The dried empty pycnometer was taken and weighed in the electrical weighing balance (W1). Now filled the water in pycnometer upto the brim and cleaned out all the moisture from outside and taken the weight. Then a small beaker was taken and added 10 gm of soil and few ml of water was added to it, then boiled for few minutes to expel all the air. After boiling allowed the beakers to cool down at room temperature then transferred the soil with a jet of water into the pycnometer and filled water completely. Then wiped out all water from outside of the pycnometer and weight was taken along with the stopper.

$$\text{Particle density} = \frac{10}{(W2+10)-W3}$$

Where, W_1= Mass of empty + dry pycnometer

W_2 = Mass of pycnometer + water

W_3 = Mass of pycnometer + water + soil

3.4.3 Determination of porosity

Porosity percentage was calculated by using the values of bulk density and particle density with the following formula.

$$\text{Porosity (\%)} = 1 - \frac{Bulk\ Density}{Particle\ Density} \times 100$$

3.4.4 Determination of Water holding capacity

The water holding capacity of soil was determined with the help of keen box **(Piper in 1966).** A round filter paper was fixed to the inner perforated base of the keen box. Then weight of keen box and filter paper was noted. Then the box was filled with soil by tapping approximately 20-30 times briskly by making the surface plane and taken the weight. The keen box with filter paper and soil was placed in petridish with water and allowed it to stand for 5-6 hours so that water may rise in keen box through the perforated bottom and soil absorbs maximum amount of water. Then placed the keen box on a filter paper sheet to drain away the excess water from it. And the keen box containing moist soil weight was noted. Then the moist soil was oven dried @ 105°C for 24 hours and weight of oven dried soil was recorded.

$$\text{Saturation \%} = \frac{Moist\ weight - Dry\ weight}{Dry\ weight} \times 100$$

3.4.5 Determination of soil pH

Estimation of soil pH was done by using pH meter **(Jackson, 1973).** A Soil solution was prepared in 1:2.5 ratio i.e, 10 gm of soil was measured and taken in a beaker and 25 ml distiiled water added to it. Kept this soil suspension aside for 30 minutes. After that stirred the soil suspension and taken readings with pH meter.

Table 3.4.5a: Classification of soil samples under pH ranges

Classes	Limit
Moderately acidic	5.6 – 6.5
Neutral	6.6 – 7.3
Strongly acidic	<5.5
Alkaline	>7.3

3.4.6 Determination of Electrical Conductivity in Soil

Electrical Conductivity represents the amount of soluble salts present in the sample and is determined by EC meter suggested by **Jackson, 1973**. A beaker was taken and prepared a soil solution in 1:2.5 ratio and allowed it to settle until the supernatant in the soil solution becomes clear. Now the readings were noted down by dipping the electrode of EC meter without touching the soil. The readings were in dSm^{-1}.

Table 3.4.6a: Classification of soil samples under salinity ranges

Classes	EC(dSm^{-1})
All crops	<0.7
Most crops	0.7-2.0
Salt tolerant	2.0-10.0
Most halophytes	10-32
No crops (sea water)	>32

3.4.7 Determination of organic carbon

Organic carbon content in the soil was determined by wet oxidation method which was suggested by **walkley and black (1934).** Firstly 1 gm of soil was taken in a 500 ml conical flask followed by 10 ml potassium dichromate solution and shaken well. Then added 20 ml of sulphuric acid to the sample and swirled the flask for 2-3 times, then allowed the conical flasks to stand for half an hour to oxidize. After that added 200ml distilled water followed by a pinch Sodium fluoride (NaF). Now 1 ml diphenylamine indicator was added and mixed well, blue colour will appear and then titrated the contents against 0.5 N ferrous ammonium sulphate until the colour of the solution turns to green and note down the titre value. Along with soil samples , a blank sample was also titrated.

$$\% \text{ Organic carbon in soil} = N \frac{B-C}{Weight\ of\ soil(g)} \times 0.003 \times 100$$

% of organic matter = organic carbon × 1.724 (Van Bemmelen factor)

Where,

N= Normality of ferrous ammonium sulphate

B = Volume of 0.5N ferrous ammonium sulphate required for blank sample titration

C = Volume of 0.5N ferrous ammonium sulphate required for titrating soil sample

3.4.8 Determination of available nitrogen

Available nitrogen in the soil is determined through Alkaline Permanganate method given by **Subbiah and Asija (1956).** Taken 5 g of soil in a distilled tube, to this 5 ml of distilled water was added to wash down the adhering soil particles at the neck of flask. After that added 25 ml of 0.34% $KMnO_4$ solution in kjeldhal flask , then to distillation tube was setup to the semi-auto analyser. Now 250 ml conical flask was taken and 20 ml boric acid of pH-4 is added and dipped the outlet tube in conical flask. Added 25 ml of sodium hydroxide solution to the distillation apparatus. The contents were distilled for about 15 minutes. Nitrogen is released in the form of ammonia gets trapped in boric acid and green colour developed . Then removed the flask and titrated it with 0.02N H_2SO_4 until the green coulour changed to pink. A Blank sample should be titrated along with soil samples.

$$\text{Available Nitrogen in soil (Kg/ha)} = \frac{(S-V) \times 0.02 \times 14 \times 10^6 \times 2.26}{1000 \times 5}$$

Where,

S= Volume of 0.02N H_2SO_4 used for titrating soil sample

V= Volume of 0.02N H_2SO_4 used for titrating blank sample

3.4.9 Determination of available phosphorus

The estimation of Soil phosphorus is done by **Olsen's, 1954** method because the collected soil samples are under neutral to alkaline in nature. If the soils are acidic nature, Bray's method should be followed. .

Olsen's method of estimation

Firstly reagent A was prepared by taking 2.5 g of soil in a 250 ml conical flask was taken and 50 ml of Olsen's reagent (0.5 M $NaHCO_3$) was added followed by a pinch of activated charcoal and the contents were allowed to shake for about 30 minutes in a rotary shaker. Then by using Whatman no: 1 filter paper , filtered the soil solution. 10 ml of aliquot was pippeted from the clear filtrate into 25 ml volumetric flask and added 2-3 drops of nitro phenol indicator , then yellow colour appears. After this the content was acidified by adding 2.5M H_2SO_4 dropwise slowly till yellow colour gets disappeared. Then added 8 ml of reagent B (Murphey Riley colour reagent) and make up the volume with distilled water upto 25 ml. The spectrophotometer was set at a wavelength of 730 nm. Firstly readings of blank sample and prepared Standards of 0, 1, 2, 3, 4, 5 ppm were noted. Then measured the intensity of blue colour in the soil samples.

Preparation of reagent A and reagent B

Reagent A	Reagent B
1. Take a beaker and add 12gm of Ammonium molybdate and to this add 250ml distilled water. 2. In a beaker take 0.0291 gm antimony potassium tartarate and add distilled water(100 ml). 3. Prepare 2.5 M H2SO4 by adding 860 ml distilled water and 140 ml Conc.H2SO4 in 1000 ml volumetric flask . Then mix the above 3 solutions in 2000 ml Volumetric flask and make up the volume.	1. Reagent B should be freshly prepared always. 2. Take a beaker and add 200 ml reagent A . 3. Then in the same beaker containing reagent A, add 1.056g of Ascorbic acid and mix well.

$$\text{Available P (Kg/ha)} = \frac{\text{R} \times \text{Volume of extractant} \times 2.24 \times 10^{6}}{\text{Volume of aliquot} \times 2.24 \times \text{wt of soil}}$$

Where

R = µg P in the extract i.e, obtained from standard curve.

3.4.10 Determination of available potassium

The estimation of available potassium in the soil is done by flame photometer instrument by using neutral normal ammonium acetate solution which was suggested by **Schollenberger and Simon (1945).** 5 g of soil sample was taken in a 250 ml conical flask and added to that 25 ml extractant (Neutral normal ammonium acetate) and left 5 min for shaking on rotary shaker. Immediately after 5 minutes filtered the contents through Whatman No.1 filter paper. Then the concentration of potassium in the filtrate was determined by flame photometer. 50 ppm and 100 ppm standards were prepared from 1000 ppm potassium chloride solution (KCl). First standard readings are recorded then sample readings are noted.

Dilution factor = 25/5 = 5 times

Flame photometer reading for the test sample = C

Available Potassium (Kg/ha) = C × 5 × 2.24

3.4.11 Determination of exchangeable calcium

The determination of exchangeable calcium in soil is done by using extractant ie., neutral normal ammonium acetate solution which was suggested by **Jackson (1973).** 5 g of soil was placed in 100 ml conical flask then added 25 ml of extractant . Then the contents were allowed for shaking in a rotatory shaker for 5 min . Immediately filtered the contents with Whatman no: 1 filter paper and calcium was estimated after pretreatment. Taken a conical flask and pipetted out 5 ml of aliquot in that and diluted it with 25 ml distilled water. Then 5 drops of 4N NaOH buffer solution followed by 50 mg of Muroxide indicator was added . Then the sample was titrated against 0.01N EDTA until the colour changes from orange red to purple and the burette reading was recorded.

$$\text{Amount of Ca (Meq L}^{-1}\text{)} = \frac{R \times Normality\ of\ EDTA \times 1000}{Aliquot\ taken(ml)}$$

$$\text{Amount of Ca (Meq/100g)} = \frac{100}{soil\ weight(g)} \times \frac{extract\ volume(ml)}{100} \times \text{Ca in Meq L}^{-1}$$

3.4.12 Determination of exchangeable calcium +magnesium

The estimation of exchangeable calcium + magnesium in soil was done by using neutral normal ammonium acetate solution suggested by **Jackson (1973)**. Taken 5 g of soil sample in 100 ml conical flask and to that added 25 ml of extractant. Then shaken the contents in a rotatory shaker for about 5 min and the contents were filtered immediately with Whatman no: 1 filter paper and calcium + magnesium were estimated after pre-treatment. After pre-treatment pippeted out 5 ml of sample in conical flask and with 25 ml distilled water it was diluted. Then 0.5 ml of ammonium chloride-ammonium hydroxide buffer and added 4 drops of Erichrome black- T indicator to the sample. Then the sample was titrated against 0.01N EDTA until the colour changes from wine red to blue and burette reading was noted down. To get the magnesium content in soil sample calcium + magnesium content in soil sample was subtracted with calcium content in soil sample.

$$\text{Amount of Ca + Mg (Meq L}^{-1}\text{)} = \frac{R \times Normality\ of\ EDTA \times 1000}{Aliquot\ taken(ml)}$$

$$\text{Amount of Ca + Mg (Meq/100g)} = \frac{100}{soil\ weight(g)} \times \frac{extract\ volume(ml)}{100} \times \text{Ca in Meq L}^{-1}$$

$$\text{Amount of Mg (Meq L}^{-1}\text{)} = \text{Ca + Mg (Meq L}^{-1}\text{)} - \text{Ca (Meq L}^{-1}\text{)}$$

Where,

R= Volume (ml) of standard EDTA used in titration

3.4.13 Determination of available sulphur

Determination of sulphur in soil is done by using Turbidimetric method **(Chesnin and Yien, 1950).** 10 g of soil sample was placed in a 250 ml conical flask and 50 ml of 0.15% $CaCl_2$ extractant was added to the sample. The contents were allowed for shaking about shaken for 30 min in a rotary shaker and filtered immediately through Whatman no: 1 filter paper. Then 10 ml of filtrate was pipette out in a 25 ml volumetric flask and added 1 g of $BaCl_2$ crystals. 2 ml of gum acacia solution to stabilize the contents and make up the volume. Then the contents were mixed well and kept it aside for 10 min. After that Absorbance reading was taken on spectrophotometer at 340 nm. First readings of prepared Working standards of 0.25, 0.5, 1.0, 2.5, and 5.0 were noted .

$$\text{Available Sulphur (mg Kg}^{-1}\text{)} = R \times \frac{50}{10} \times \frac{1}{10}$$

Where, R stands for S content in µg as read on X-axis

3.4.14 Determination of Micronutrients

Determination of micronutrient content present in the soil is done by using DTPA extractant. Firstly 10 gm of soil sample was taken in a 250 ml capacity conical flask. 20ml of DTPA solution (0.005M DTPA +0.1 M TEA + 0.011 M $CaCl_2.2H_2O$) was added to the sample. Then the content was allowed for shaking about 2 hrs on rotary shaker. Immediately after 2 hrs , filtered the contents through Whatsman No. 42 filter paper. Then the obtained clear filtrate was used for estimating Micronutrients (Fe,Cu,Mn and Zn) in Atomic Atmospheric Spectrophotometer.

$$\text{Available micronutrients in soil(mg/kg)} = \frac{A \times 20}{10}$$

Where,

A = Concentration of Micronutrient in aliquot as read from X – axis of standard curve against sample reading.

3.4 Rating chart of soil nutrients

Nutrients	LOW	MEDIUM	HIGH
Organic carbon (%)	<0.5	0.5-0.75	>0.75
Available N (kg ha^{-1})	<280	280-560	>560
Available P (kg ha^{-1})	<10	10-25	>25
Available K (kg ha^{-1})	<135	135-335	>335
Available S (mg kg^{-1})	<10	10-20	>20
	DEFICIENT	**SUFFICIENT**	
Magnesium(Meq/100g)	<1.5	>1.5	-
Calcium (Meq/100g)	<1.0	>1.0	-

3.5 Evaluation of Soil Nutrient Index

In order to compare the fertility levels of soil from one area to the other area it is necessary to procure a single value for each and every nutrient. Soil Nutrient Index is nothing but a measure of capacity of soil to supply nutrients to plants. The nutrient index approach was introduced by **Parker *et al.* (1951)** and it has been taken up and altered by several researchers and National or International organizations viz., ICAR-NBSS &LUP, Food and Agricultural Organization (FAO), Ministry of Agriculture etc., This index is calculated by using the following formula which was given by **Muhr *et al.*(1963).**

Soil Nutrient Index =

$$\frac{\%\text{ in high category} \times 3 + \%\text{ in medium category} \times 2 + \%\text{ in low category} \times 1}{100}$$

3.5a Rating chart of soil nutrient index

Nutrient index	Range	Interpretation
Low	< 1.67	Low fertility status
Medium	1.67- 2.33	Medium fertility status
High	>2.33	High fertility status

3.6 Method of water sampling and preservation

In this study, ground water samples were collected from different locations in plastic bottles. Total 40 water samples were collected from different sites/villages in Cuddapah Block from YSR district, Andhra Pradesh. Added 2-3 drops of toluene to the collected water samples to prevent the growth of microbes.

3.7 Chemical analysis

The analysis of chemical parameters in the water samples was done by using standard methods given by **APHA, 1992.**

3.7.1 Measurement of water pH

To measure the pH of water, taken required amount of water sample in 50 ml beaker and measured by using pH meter as suggested by **APHA, 1992.**

3.7.2 Measurement of water salinity

The amount of soluble salts present in water sample is expressed in EC. To measure EC in water sample, the required amount of water sample was taken in 50ml capacity beaker and measured using EC meter as suggested by **APHA, 1992.** EC is expressed in dSm^{-1}.

3.7.3 Determination of alkalinity (carbonate and bicarbonate)

Determination of Carbonates and Bicarbonates in water samples was done by Simple Acidimetric titration method as described by **APHA in 1992.** Firstly , 5 ml of water sample was taken in a clean conical flask and added 25 ml distilled water and diluted it. Now added 2-3 drops of phenolphthalein indicater to the samples. As the colour did not turn to pink which indicates the absence of carbonates in the collected water samples. Then 2-3 drops of methylorange indicator was added to the same colourless water solution, yellow colour was noticed. Then the solution was titrated against 0.01N H2SO4 till the yellow colour turned out to rosy red and the titre value was recorded.

$$CO_3^{2-}\ \text{Meq}\ L^{-1} = \frac{\text{Normality of H2SO4} \times \text{vol of H2SO4} \times 1000}{\text{ml of aliquot taken}}$$

$$CO_3^{2-}\ \text{gram/lit} = \frac{\text{Normality of H2SO4} \times \text{vol of H2SO4}}{\text{ml of aliquot taken}} \times \text{Eq.wt of } CO_3^{-}\ (30)$$

$$HCO_3^{-} = \frac{\text{Normality of H2SO4} \times \text{vol of H2SO4} \times 1000}{\text{ml of aliquot taken}}$$

$$HCO_3^{-} = \frac{\text{Normality of H2SO4} \times \text{vol of H2SO4}}{\text{ml of aliquot taken}} \times \text{Eq.wt of } HCO_2^{3-}\ (61)$$

3.7.4 Determination of chloride

Chloride ion estimation in water samples was done by using Mohr's titration method **(APHA, 1992).** A conical flask was taken and added 5 ml of water sample in that and diluted it with 25 ml of distilled water. Then 5-6 drops of potassium chromate indicator (K2CrO4) was added to the solution and the colour water solution was changed to dark yellow. Then the solution was titrated against the standard 0.02N silver nitrate solution until the colour turns from dark yellow to brick red .

$$Cl^{-}\ Meq\ L^{-1} = \frac{\text{Normality of AgNO3} \times \text{vol of AgNO3} \times 1000}{\text{ml of aliquot taken}}$$

$$Cl^{-}\ Meq\ L^{-1} = \frac{\text{Normality of AgNO3}\times\text{vol of AgNO3}}{\text{ml of aliquot taken}} \times \text{Eq.wt of } Cl^{-}\ (35.5)$$

3.7.5 Determination of calcium + magnesium

The total Calcium and magnesium ions present in the water samples were determined by Complexometric titration method. 5 ml of water sample was taken in a clean conical flask and diluted it by 25 ml of distilled water. Then added 1 ml of ammonium hydroxide-ammonium chloride buffer solution followed by a pinch of carbamate crystals in order to prevent the interference with other metal ions. Then added 2-3 drops of Erichrome Black-T indicator to the solution , and noticed the initial colour was wine red. Now it was titrated against 0.01N EDTA solution until the final colour changed to blue.

$$Ca^{2+} \text{ and } Mg^{2+}\ Meq\ L^{-1} = \frac{\text{Normality of EDTA} \times \text{vol of EDTA} \times 1000}{\text{ml of aliquot taken}}$$

$$Ca^{2+}\text{and } Mg^{2+}\text{gram/lit} = \frac{\text{Normality of EDTA} \times \text{vol of EDTA}}{\text{ml of aliquot taken}} \times \text{Eq.wt of } Ca^{2+} \text{ and } Mg^{2+}$$

3.7.6 Determination of calcium

Determination of Calcium in the water samples was done by Complexometric titration method. Firstly 5 ml of water sample was taken in a conical flask and was diluted it with 25 ml of distilled water. Then 5 ml of sodium hydroxide buffer solution was added and a pinch of carbamate crystals were added to prevent the interference with other metal ions. About 25 mg of ammonium purpurate or mixed Muroxide indicator (0.5g Muroxide +40g potassium sulphate) swas added , then the initial colour was turned into pink. After that titrated against 0.01N EDTA solution until the colour changed from pink to blue.

$$Ca^{2+}\ Meq\ L^{-1} = \frac{\text{Normality of EDTA} \times \text{vol of EDTA}\times 1000}{\text{ml of aliquot taken}}$$

$$Ca^{2+} gram/lit = \frac{\text{Normality of EDTA} \times \text{vol of EDTA}}{\text{ml of aliquot taken}} \times Eq.wt\ of\ Ca^{2+} \quad (20)$$

3.7.7 Determination of potassium

The concentration of potassium present in water samples were determined by flame photometer as described by **APHA, 1992.**

Preparation of standards for calibrating Flame Photometer

Firstly, 1000 ppm of KCl standard stock solution was prepared and 10 ml of concentrate was taken from that stock solution and added in volumetric flask which is of 100 ml capacity and make up the volume that gives 1000 ppm concentration. To prepare 50 ppm concentration , 5 ml was taken from 1000 ppm stock solution and added in 100 ml volumetric flask and make up was done to give 50 ppm. Different Standards like 0, 2, 4, 6, 8, 10 ppm were prepared from 100 ppm in 100 ml volumetric flask. Then calibrated the flame photometer with standards and after readings of samples were taken.

3.7.8 Determination of sodium

The sodium concentration present in water samples were determined by flame photometer as given by **APHA, 1992.**

Preparation of standards for calibrating flame photometer

Firstly, 1000ppm of NaCl standard stock solution was prepared and taken 10 ml of concentrate from that stock solution and added in 100 ml volumetric flask and volume make up was done which gives 100 ppm concentration. And taken 5 ml from 1000 ppm stock solution and added in 100 ml capacity volumetric flask and make up the volume which gives 50 ppm concentration. Then flame photometer was calibrated with different standards of 0,2,4,6,8,10 ppm which were prepared from 100 ppm concentration in 100 ml capacity volumetric flask. After calibrating the flame photometer with these standards, the readings of water samples was taken.

3.7 Rating chart of water parameters

Parameters	Suitable	Moderately suitable	Not suitable
pH	6.5 – 8.4	0 – 5.0	>9.5
EC(dSm^{-1})	<0.3	3.0 – 7.0	>7.0
HCO_3^-(Meq L^{-1})	>1.25	1.25 – 8.5	8.5
Cl^-(Meq L^{-1})	<4.0	4.0 – 10.0	>10.0
Na^+(Meq L^{-1})	<3.0	3.0 – 9.0	>9.0

(Source: FAO.org)

3.8 Irrigation Water Quality Index (IWQI)

The various water quality indices were derived from primary parameters which refers to its suitability for use in agriculture. The quality for irrigation can be determined by the concentration and composition of dissolved components. Water quality is an important consideration for determining the salinity or alkalinity of the irrigated area. The requirements for irrigation water quality could differ from one field to the other depending on the cultivated crop pattern as well as the regional soil and climatological conditions **(Babiker *et.al.* 2007)** IWQI model was developed by **(Meireles *et. al*. 2010)** and this model was applied on the data.

Computation of WQI : The WQI is computed by the following three steps

First step: weight has been assigned (w_i) to each of the selected water parameters (e.g. pH, HCO3, Cl, EC, Na, K…..etc) according to its relative importance in the overall quality of water.

Second step: Computed the relative weight (W_i) of the chemical parameter from the following equation :

$$W_i = w_i / \Sigma w_i \text{ (i=1 to n)}$$

Where, W_i = is the relative weight

W_i = Weight of each parameter

n = Number of parameters

Third step: quality rating scale (q_i) for each parameter has been assigned as below:

$$q_i = (C_i / S_i) \times 100$$

Where, q_i = quality rating

C_i = Concentration of each chemical parameter in each water sample in mg/l

S_i = Guide line value given in BIS 1991

For computating the WQI, the sub-index (SI) is first determined for each chemical parameter and then used to determine WQI as given below:

$$SI_i = W_i \times q_i$$

$$WQI = \Sigma SI_i$$

Where, SI_i = sub index of i^{th} parameter

W_i = Relative weight of i^{th} parameter

q_i = Rating based on concentration of i^{th} parameter

n = Number of chemical parameters

Quality of water is an important consideration in any appraisal of salinity or alkali conditions in an irrigated area. Good quality water has the potential to cause maximum yield under good soil and water management practices. The most important characteristics of water, which determine suitability of ground water for irrigation purpose are as follows: salinity, relative proportion of sodium to other cation i.e, Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Kelly's ratio (KR), Soluble Sodium Percentage (SSP) and Permeability Index (PI). Safe limit of electrical conductivity for crops of different degrees of salt tolerances under varying soil textures and drainage conditions is variable. The quality of water is commonly expressed by classes of relative suitability for irrigation with reference to salinity level. The recommended classification with respect to electrical conductivity, sodium content, sodium adsorption ratio and residual sodium carbonate, Kelly's Ratio, Soluble Sodium Percentage and Permeability Index.

Table 3.8a: Range of WQI quality status and conceivable usage of water

WQI	Water quality	Usage
<50	Excellent	Irrigation, drinking and industrial use
50-100	Good	Irrigation,drinking and industrial use
100-200	Poor	Irrigation and industrial use
200-300	Very poor	Only irrigation
>300	Unsuitable	Appropriate treatment is essential

(Source of information : *Anbazaghan,2014*)

Table 3.8b: Water quality standards for different parameters (except pH and EC, all are in mg/l)

Parameters	Standard values
pH	7.5
Electrical Conductivity	0.3
Bicarbonate	300
Chloride	250
Calcium	75
Magnesium	30
Sodium	200
Potassium	20

(Source of information : *BIS 1991*)

3.8.1 Sodium Adsorption Ratio (SAR)

SAR is a measure of relative ratio of sodium (Na^{+}) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the water sample. Water having higher Sodium Adsorption Ratio mean that it has high exchangeable sodium percentage and low permeability. SAR in water is calculated by using following formula and concentration of all the ions are expressed in Meq L^{-1}.

$$SAR = \frac{Na}{\sqrt{Ca+Mg/2}}$$

Table 3.8.1a: Classification of irrigation water based on SAR values (Richards)

SAR	Class
0-10	Low
10-18	Medium
18-26	High
>26	Very high

3.8.2 Residual sodium carbonate (RSC)

Residual sodium bicarbonate is an index which represents the amount of carbonates and bicarbonates of sodium ($NaCO_3$ and $NaHCO_3$) present in the irrigation water hazard in water. The RSC is calculated by using the following formula which has been developed by **Eaton (1950)** it is expressed in Meq L^{-1}.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Table 3.8.2a: Classification of irrigation water based on RSC values

RSC	Water quality
<1.25	Suitable
1.25-2.50	Moderately suitable
>2.50	Not suitable

3.8.3 Soluble sodium percentage

Soluble sodium percentage gives a clear idea about sodium content which is important for studying sodium hazard. High SSP retards the growth of plants and reacts with soil in turn reduces its permeability. The SSP in water is calculated by using the following formula and concentration of all the ions are expressed in Meq L^{-1} .

$$SSP = \frac{Na \times 100}{Ca+Mg+Na}$$

If SSP value is < 50 indicates that water is of good quality where as SSP values > 50 indicates that water is not safe for irrigation.

Table 3.8.3a: Classification of irrigation water based on SSP values (Todd)

SSP	Class
<20	Excellent
20-40	Good
40-60	Permisssible
60-80	Doubtful
>80	Unsuitable

3.8.4 Permeability Index (PI)

Permeability is the capability of water movement in the soil and Permeability Index(PI) indicates the suitability of water for irrigatin purpose.The permeability is influenced by the longterm application of irrigation water which rises the amount of sodium, calcium, magnesium and bicarbonate (Na^{+},Ca^{2+}, Mg^{2+} and HCO_3^{-})ions in the soil (Chandu et al 1995). Permeability Index (PI) in water is calculated by using the following formula which has been developed by **(Doneen, 1964)** and all the ions are expressed in Meq L^{-1}.

$$PI = \frac{Na + \sqrt{HCO3}}{Ca + Mg + Na} \times 100$$

If Permeability Index (PI) values are >75,it indicates water is of excellent quality for irrigation. If the PI values are found between 25 and 75,water is having good quality for irrigation whereas PI values are < 25 indicates water is unsuitable for irrigation.

Table 3.8.4a: Classification of irrigation water based on PI values

Permeability Index	Water Quality
>75	Suitable
25-75	Moderately suitable
<25	Not suitable

3.8.5 Kelly's Ratio (KR)

Kelly's ratio **(Kelly,1953)** is a factor which is used to assess the quality and suitability of water for irrigation purposes . The ratio of concentration of sodium against calcium and magnesium is used as Kelly's ratio. Groundwater having KR >1 is considered as not-suitable for irrigation purpose and ground water having KR <1 is considered as suitable for irrigation. Kelly's ratio in the water sample was calculated by using the following formula and is expressed in Meq L^{-1}.

$$KR = \frac{Na^{+}}{Ca^{2+} + Mg^{2+}}$$

3.9 Statistical Analysis

By using SPSS statistical software the standard measures like mean, Range, coefficient of variation and Standard Deviation were calculated based on the statistical data obtained from soil as well as water analysis. The formulas used for computing the statistical data are as follows :-

1. Mean = $\frac{Sum\ of\ all\ samples}{Total\ number\ of\ samples}$

2. Range = largest value - smallest value

3. Coefficient of variation = $\frac{Standard\ Devation}{mean} \times 100$

4. Standard Deviation = $\sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$

Where, ΣX^2 = Sum of all samples

$(\Sigma x)^2$ = Sum of squares of all samples

n = Total number of samples

5. Coefficient of Correlation (Karl Pearson) = $\frac{SS(XY)}{\sqrt{[SS(X)][SS(Y)]}}$

Where, SS (XY) = Sum of the product of x and y

SS(X) = Sum of squares of x

SS(Y) = Sum of squares of y

Chapter IV

RESULTS AND DISCUSSION

The present chapter deals with the results and discussion of Characterization of soil and water quality parameters which were collected from Cuddapah block. Total of 40 soil samples and 40 water samples were collected from different fields and locations and analysed for their major quality parameters (Physical and chemical). The results of the study were correlated, interpreted and feasible reasons for variation were discussed in detail under this chapter. The results of each parameter are given out under the following :

4.1 Analysis of soil parameters

4.1.1 Physico-chemical properties of soil.

4.1.2 Status of available primary macronutrients in the soil (N,P,K)

4.1.3 Status of available secondary macronutrients in the soil (Ca,Mg,S)

4.1.4 Status of available micronutrients in the soil (Fe,Mn,Cu,Zn)

4.1.5 Correlation matrix between physical and chemical properties of soil.

4.2 Analysis of water parameters

4.2.1 Chemical parameters of ground water

4.2.2 Status of anions in ground water

4.2.3 Status of cations in groundwater.

4.2.4 Irrigation water quality index

4.2.5 Correlation matrix between chemical properties of ground water.

4.1 Analysis of soil parameters

4.1.1 Physico-Chemical properties of soil

The obtained data on physico-chemical analysis of soil properties are given in the Table 4.1.1 and Appendix 2 and 3.

The results showed that the Bulk density of the soil samples were found to be in the range of 1.17-1.47 Mg/m^3 with a mean value of 1.32 Mg/m^3. The Standard deviation and Coefficient of variation values of bulk density have been recorded as 0.07 and 5.55%.The highest bulk density was noticed in site 3 sample no: 10 putlampalli village and the lowest bulk density was noticed in site 1 sample no: 1 mamillapalli village.

The highest bulk density was found in cultivated land as a result of high intensive agricultural practices which leads to soil compaction in the field. A similar observation has been reported by **Chaudari *et al.* (2013)** in soils of Coimbatore district. The particle density of the soil samples were found to be in the range of 2.08 to 2.64 Mg/m^3 with a mean value of 2.37 Mg/m^3. The standard deviation and coefficient of variation values of particle density have been recorded as 0.138 and 5.82%.

The highest particle density was noticed in site 8 sample no: 29 apparajupalli and lowest particle density was noticed in site 6 sample no: 22 chalamareddypalli and this may be owing to the presence of high organic carbon content in the soil. The values of porosity were found to be in the range of 37.03-50.2% with a mean value of 44.08% whereas standard deviation and coefficient of variation of porosity have been recorded as 4.05 and 9.20%.The lowest porosity was noticed in site 6 sample no: 24 chalamareddypalli and the highest porosity was noticed in site 10 sample no: 38 subbanavaripalli .When soil particles become eroded they fill up the pore spaces there upon increases the bulk density of the soil by decreasing the porosity and identical results were reported in the soil samples. Sample no: 24 showed low porosity due to high bulk density (1.36 g/cm^3) of 24 th sample and sample no: 38 showed high porosity due to low bulk density (1.20 g/cm^3) of 38th sample.

Values of water holding capacity were found to be in the range of 33.4-56.4% with a mean value of 43.4 % whereas standard deviation and coefficient of variation have been observed as 6.11 and 14.09% . The lowest water holding capacity was observed in site 4 sample no: 14 nanapalli village this is due to the presence of low organic carbon content in the soil samples no: 14 and the highest water holding capacity was observed in site 9 sample no: 33 peddamusalreddyypalli village as there is high organic carbon content of 0.65% in sample no: 33.

Table 4.1.1. Statistical data on physico-chemical properties of soil

Soil parameters	Mean	Range	S.D±	C.V(%)
Bulk density(Mg/m^3)	1.32	1.17-1.47	0.07	5.55
Particle density(Mg/m^3)	2.37	2.08-2.64	0.13	5.82
Water holding capacity (%)	43.4	33.4-56.4	6.11	14.09
Porosity(%)	44.08	37.03-50.2	4.05	9.2
pH	7.6	6.8-8.5	0.51	6.69
EC(dSm^{-1})	0.527	0.094-1.273	0.32	62.4
Organic carbon(%)	0.63	0.24-1.18	0.24	39.3

So the results revealed that with increasing organic carbon content higher will be the water holding capacity. This observation is in conformity with the data reported by **Deb *et al*. (2013)** while studying about soils of south Sikkim and **Nath (2014)** in soils of Sivasagar district, Assam.

Values of pH in the soil samples were found to be in the range of 6.8-8.5 with a mean value of 7.6 whereas standard deviation and coefficient of variation have been recorded as 0.51 and 6.69%. The lowest pH value was observed in site 1 sample no: 4 mamillapalli village, site 2 sample no:8 modimedapalli village and site 6 sample no: 21 chalamareddy palli village and the highest pH value was observed in site 3 sample no: 11 putlampalli village and site 5 sample no: 17 jamalpalli village. The results revealed that 72.5% of the samples are alkaline in nature and 27.5% of the samples are neutral in nature. Similar results has been observed by **Vijakumar .R *et al.* (2011)** in Tamil Nadu state and **Srivastava *et al*. (2017)** in soils of Bihar and Jharkhand.

Table 4.1.1a: Classification of soil samples under different pH range

Classes	Limit	No. of samples	% of samples
Moderately acidic	5.6-6.5	0	0%
Neutral	6.6-7.3	11	27.5%
Strongly acidic	<5.5	0	0%
Alkaline	>7.3	29	72.5%

(Source: Natural Resource Conservation Service)

Values of EC were found to be in the range of 0.09-1.273 dSm^{-1} with a mean value of 0.527 dSm^{-1} whereas standard deviation and coefficient of variation have been recorded as 0.32 and 62.4%. The lowest EC was noticed in site 1 sample no: 4 mamillapalli village and the highest EC was noticed in site 10 sample no: 37 subbanavaripalli village. In accordance with results it was observed that 67.5% of the samples are in permissible range and suitable for all type of crops and 32.5% of the samples have shown slightly higher than the permissible range but suitable for most of the crops. This findings are being in conformity with the observation that has been made by **Kumar *et al*. (2017)** while investigating the soils of Himachal Pradesh.

Table 4.1.1b: Classification of soil samples under different EC range

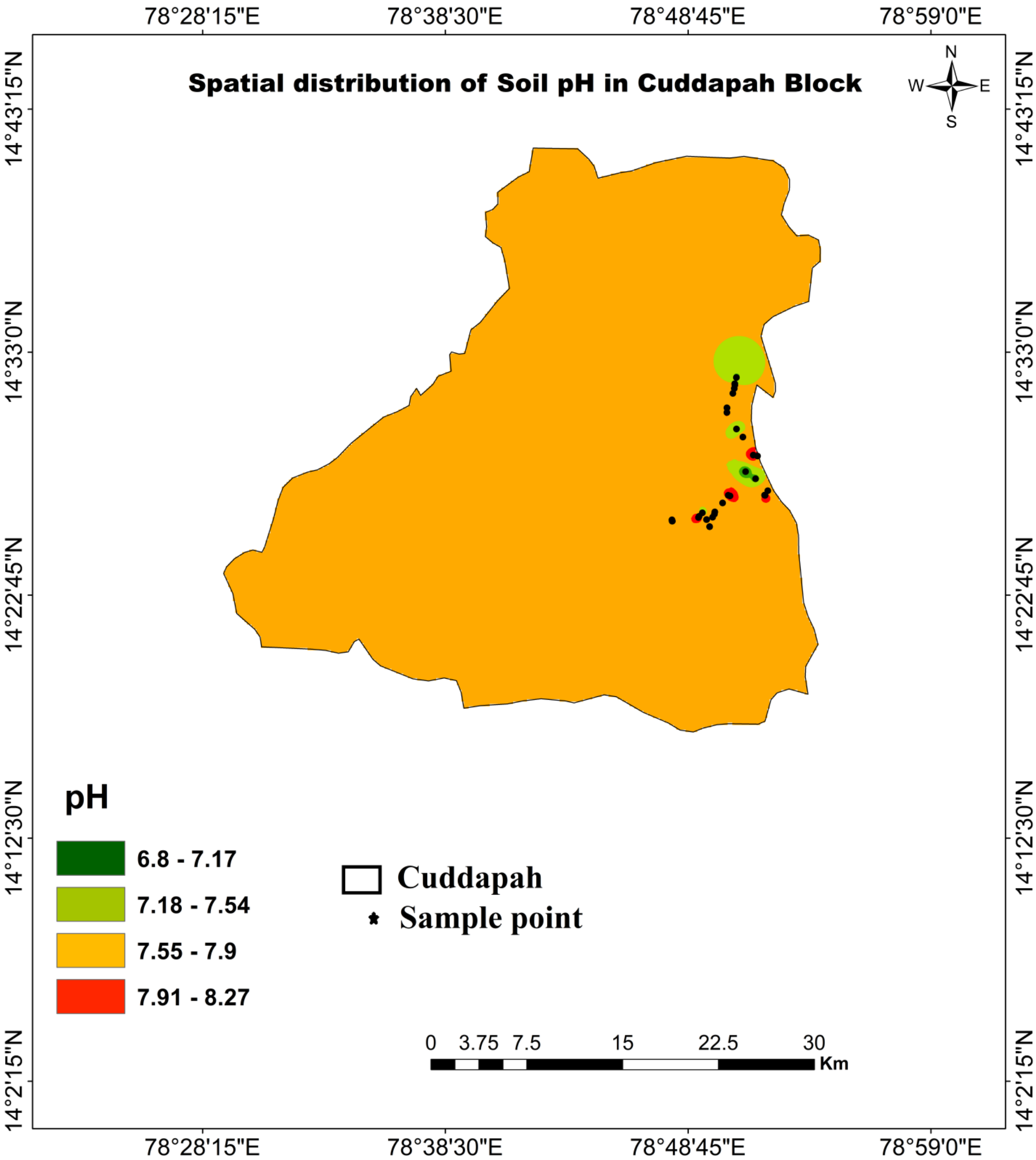
Classes	Limit	No. of samples	% of samples
All crops	<0.7	27	67.5%
Most crops	0.7-2.0	13	32.5%
Salt tolerant	2.0-10.0	0	0%
Most halophytes	10-32	0	0%
No crops(sea water)	>32	0	0%

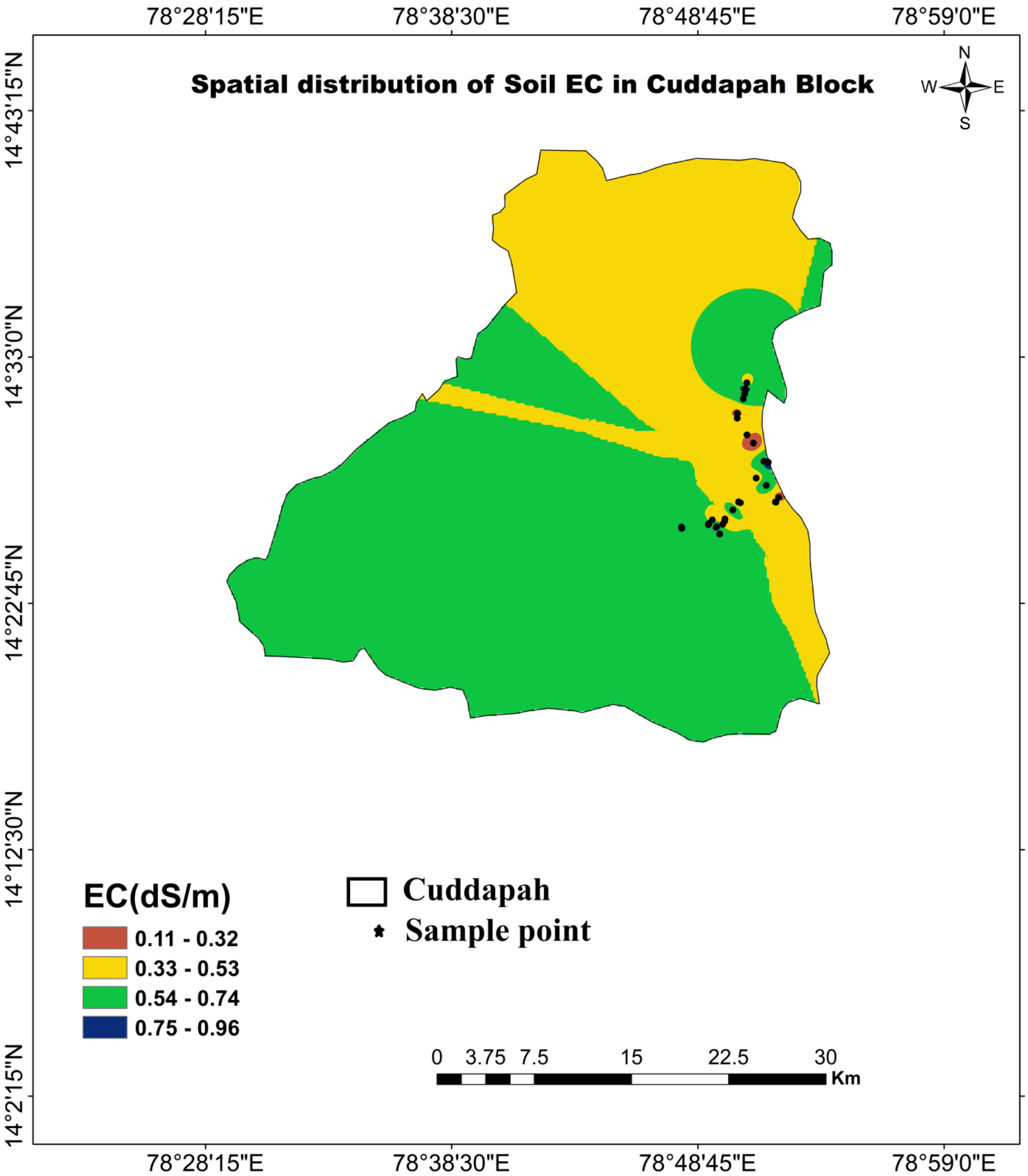
The values of organic carbon content in the soils were found to be in the range of 0.24-1.18% with a mean value of 0.63% whereas standard deviation and coefficient of variation of organic carbon have been recorded as 0.24 and 39.3%. The lowest organic carbon content was reported in site 2 sample no: 6 modimedapalli and the highest organic carbon content was reported in site 9 sample no:35 peddamusalreddypalli. Out of total soil samples in Cuddapah block 37.5% of the soil samples are in high organic carbon cotent, 32.5% of the soil samples are in medium and 30% of the soil samples are in high organic carbon content. More than 50% of the soil samples ascertained as medium to high in range of organic carbon content which may be due to low temperatures in the zone that inhibits the microbial and enzymatic activity hence decomposition of organic matter will become less and accumulation on the soil surface.

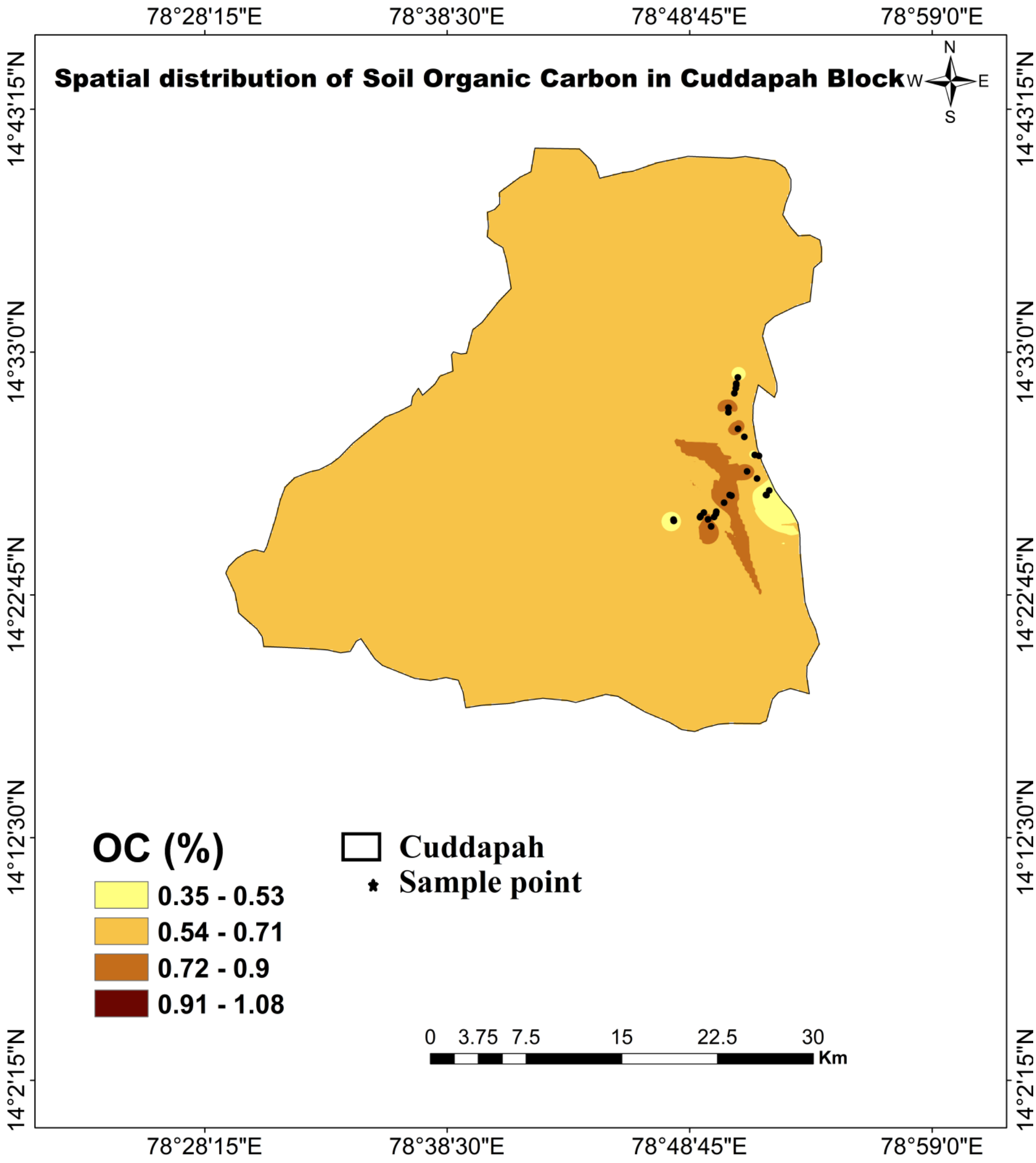
Table 4.1.1c: Classification of soil samples under different organic carbon range

Classes	Limit	No. of samples	% of samples
Low	<0.25	15	37.5%
Medium	0.25-0.75	13	32.5%
sHigh	>0.75	12	10%

(Source: Muhr et. al, 1963)


Spatial distribution of Soil pH in Cuddapah Block
N
W
E
S
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
pH
6.8 - 7.17
7.18 - 7.54
7.55 - 7.9
7.91 - 8.27
Cuddapah
Sample point
0
3.75
7.5
15
22.5
30
Km


Spatial distribution of Soil EC in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
S
W
E
EC(dS/m)
0.11 - 0.32
0.33 - 0.53
0.54 - 0.74
0.75 - 0.96
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km


Spatial distribution of Soil Organic Carbon in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
S
W
E
OC (%)
0.35 - 0.53
0.54 - 0.71
0.72 - 0.9
0.91 - 1.08
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km

4.1.2 Status of available primary macro-nutrients in the soil

The resulted data on available primary macronutrients i.e, Nitrogen, Phosphorous and Potassium in the soil were presented in Table 4.1.2 and in Appendix 4.

Values of available nitrogen content in the soil samples were found to be in the range of 76.3 – 708.2 kg/ha with a mean value of 298.4 kg/ha whereas standard deviation and coefficient of variation of available nitrogen has been recorded as 182.9 and 61.2%. The lowest nitrogen content was observed in site 5 sample no:18 jamalpalli and the highest nitrogen content was observed in site 9 sample no:35 peddamusalreddypalli. 57.5% of the soil samples have reported low levels of nitrogen,32.5% of the soil samples have reported medium levels and 10% of the soil samples reported high nitrogen levels. Similar observations has been made by Dameswar *et al*. (2018) in kaslol block of Matya village, Chattisgarh.

Table 4.1.2a: Classification of soil samples under different nitrogen range

Classes	Limit	No. of samples	% of samples
Low	<280	23	57.5%
Medium	280-560	13	32.5%
High	>560	4	10%

(Source: Muhr et.al, 1963)

Values of available phosphorous content in the soil samples were found to be in the range of 4.18-44.92 kg/ha with a mean value of 19.5 kg/ha whereas standard deviation and coefficient of variation of available phosphorous has been recorded as 12.4 and 63.6% respe ctively. The lowest phosphorous content was observed in site 8 sample:30 apparajupalli and the highest phosphorous content was observed in site 2 sample:7 modimedapalli. Out of total soil samples 37.5% of the samples were found in low phosphorous range due to alkaline nature of soil which in turn causes fixation of phosphorous ion by Ca, Mg and Na oxides whereas 30% of the soil samples are in medium range and 32.5% of the samples are in high phosphorous range.

Table 4.1.2b: Classification of soil samples under different phosphorous range

Classes	Limit	No. of samples	% of samples
Low	<10	15	37.5%
Medium	10-25	12	30%
High	>25	13	32.5%

Values of available potassium content in the soil samples were found to be in the range of 78.6-864.4 kg/ha with a mean value of 385.8 kg/ha whereas standard deviation and coefficient of variation of potassium content has been recorded as 189.1 and 49.0%. The lowest potassium content was noticed in site 1 sample no:4 mamillapalli and the highest potassium content was noticed in site 8 sample no:29 apparajupalli. Among the total soil samples 52.5% of the samples are noted as high potassium range which may be by the reason of presence of elite rich potassium content in the soils,40% of the samples were found in medium range and 7.5% of the samples were found in low potassium range. Identical results were reported by **Jain *et al*. (2014)** who has conducted a study on fertility status of soils in Lunawada taluk of Gujarat.

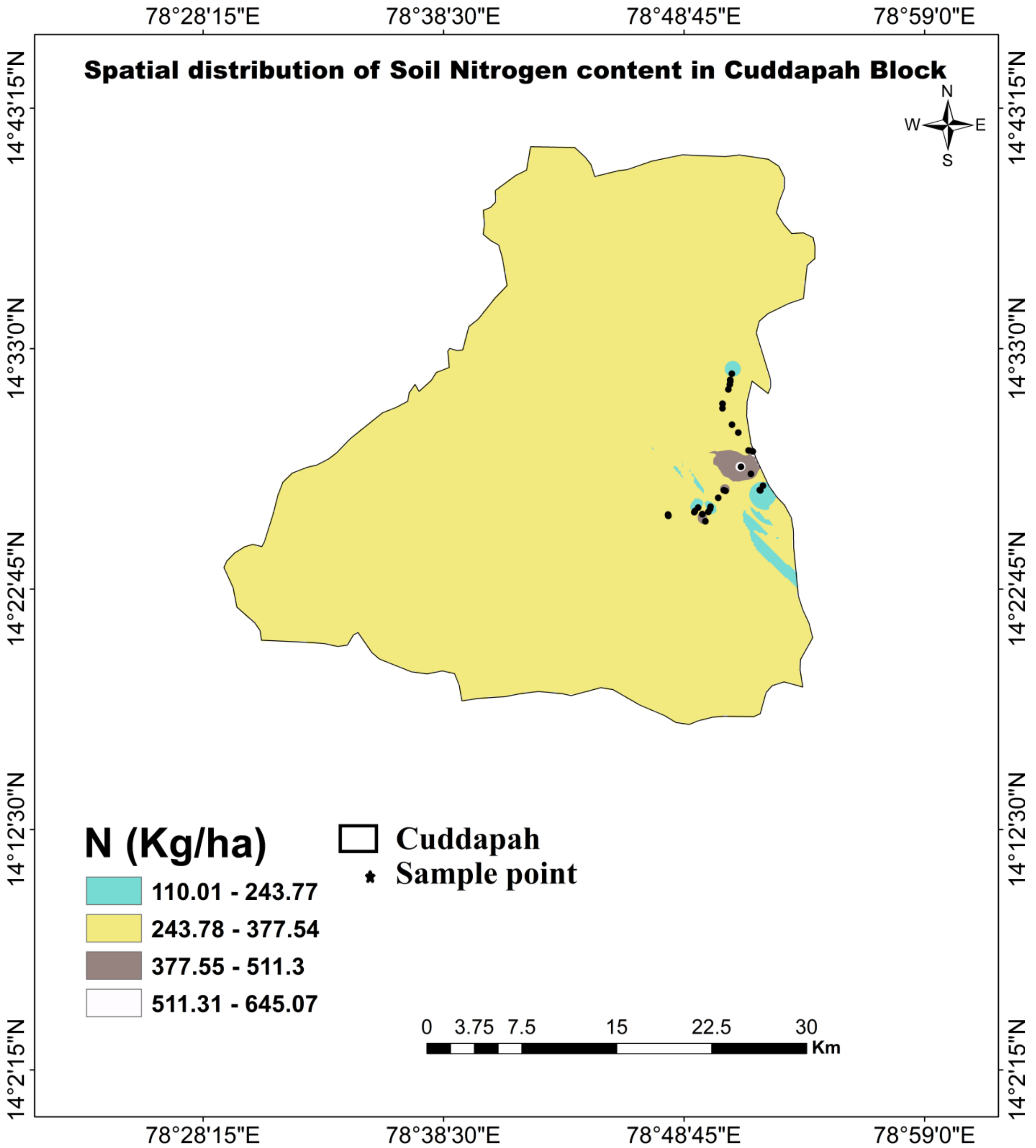
Table 4.1.2c: Classification of soil samples under different potassium range

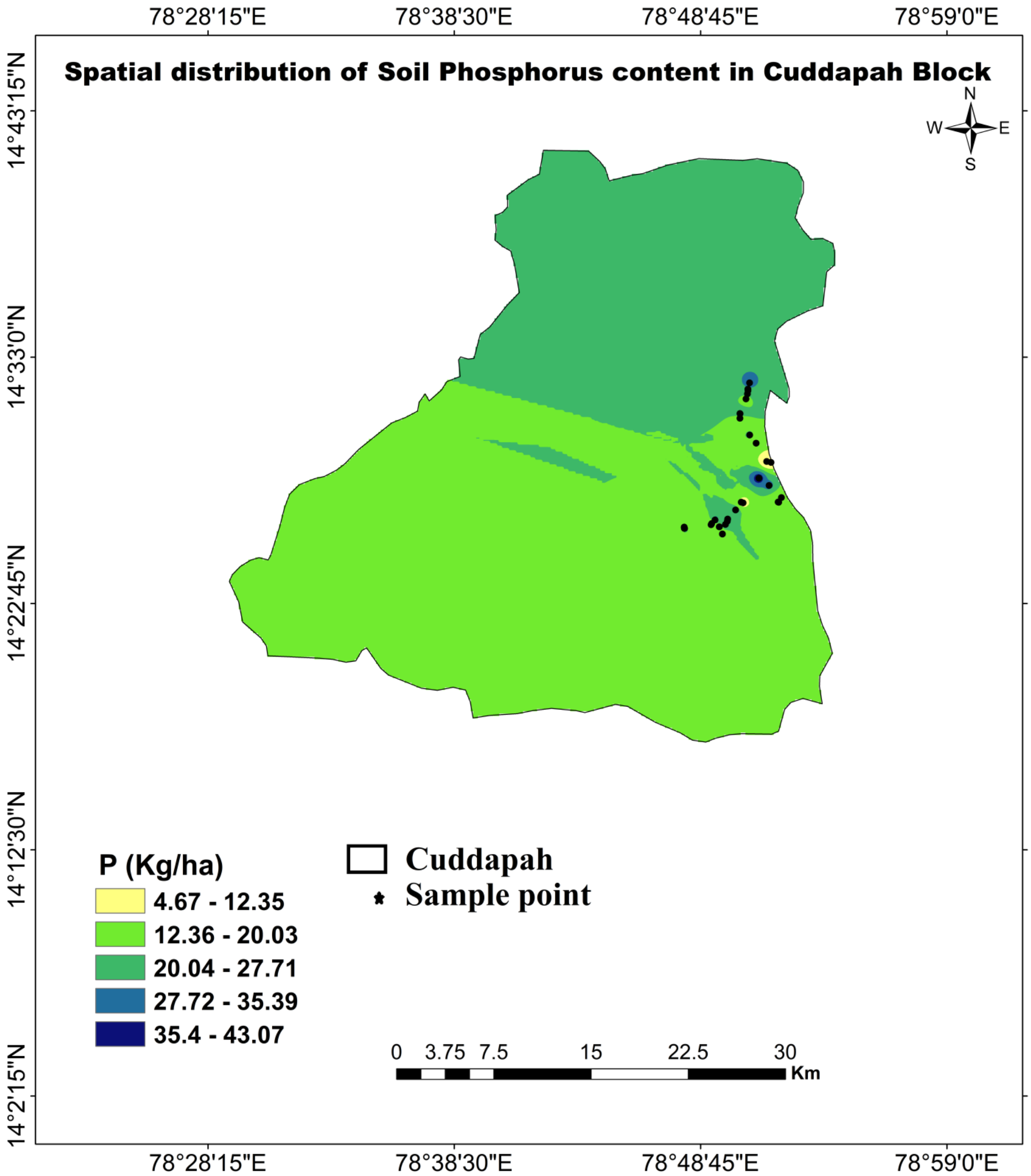
Classes	Limit	No. of samples	% of samples
Low	<135	3	7.5%
Medium	135-335	16	40%
High	>335	21	52.5%

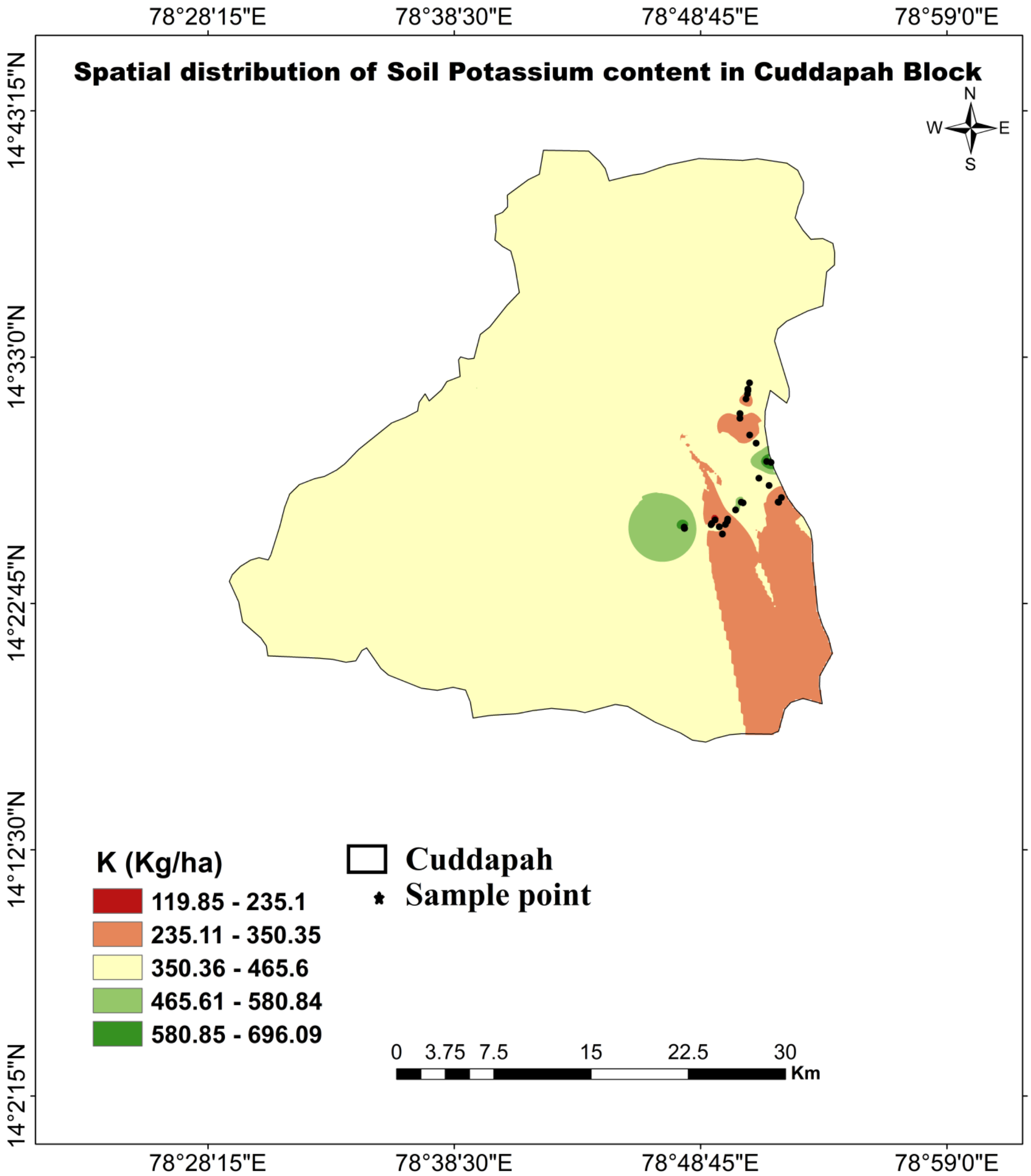
(Source: Ramamoorthy and Bajaj, 1969)

Table 4.1.2: Statistical data on primary macronutrients of soil

Soil parameters	Range	Mean	SD±	C.V(%)
Nitrogen	76.3-708.2	298.4	182.9	61.29
Phosphorous	4.18-44.9	19.5	12.4	63.6
Potassium	78.6-864.4	385.8	189.1	49.0


Spatial distribution of Soil Nitrogen content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
N (Kg/ha)
110.01 - 243.77
243.78 - 377.54
377.55 - 511.3
511.31 - 645.07
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km


Spatial distribution of Soil Phosphorus content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
P (Kg/ha)
4.67 - 12.35
12.36 - 20.03
20.04 - 27.71
27.72 - 35.39
35.4 - 43.07
Cuddapah
Sample point
0
3.75
7.5
15
22.5
30
Km



Spatial distribution of Soil Potassium content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
K (Kg/ha)
119.85 - 235.1
235.11 - 350.35
350.36 - 465.6
465.61 - 580.84
580.85 - 696.09
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km

4.1.3 Status of available secondary macro-nutrients in the soil

The resulted data on analysis of secondary macronutrients (Calcium. Magnesium and Sulphur) in the soil is given in the table 4.1.3 and Appendix 5.

Values of Calcium content in the soil samples were found to be in the range of 0.43-6.7 Meq/100gm with a mean value of 2.49 Meq/100gm whereas standard deviation and coefficient of variation of calcium has been recorded as 1.25 and 50.3% respectively. The highest calcium content was observed in site 8 sample no:32 apparajupalli and the lowest calcium content was observed in site 6 sample no: 22 chalamareddy palli. Among the total soil samples 77.5% of the samples were found in high calcium levels whereas 22.5% of the samples were found in low calcium range.

Table 4.1.3a: Classification of soil samples under different calcium range

Classes	Limit	No. of samples	% of samples
Low	<1.5	9	22.5%
High	>1.5	31	77.5%

(Source:Ramamoorthy and Bajaj, 1969)

Values of magnesium content in the soil samples were found to be in the range of 0.18 – 2.72 Meq/100 g with a mean value of 0.87 Meq/100 g whereas standard deviation and coefficient of variation of magnesium have been recorded as 0.60 and 68.76%. The lowest magnesium content was observed in site 5 sample no: 20 jamalpalli and the highest magnesium content was observed in site 8 sample no: 29 apparajupalli. 62.5% of the soil samples were found in low range whereas 37.5% of the soil samples were found in low magnesium range.

Table 4.1.3b: Classification of soil samples under different magnesium range

Classes	Limit	No. of samples	% of samples
Low	<1.0	25	62.5%
High	>1.0	15	37.5%

(Source:Ramamoorthy and Bajaj, 1969)

Values of available sulphur content in the soil samples were found to be in the range of 0.16-1.14 mg/kg with a mean value of 0.45 mg/kg whereas standard deviation and coefficient of variation of sulphur have been recorded as 0.24 and 53.9%. The lowest sulphur content was reported in site 6 sample no: 21 chalamareddypalli and the highest sulphur content was found in sample no: 24 in chalamareddypalli. The results in the present investigation revealed that all the 40 samples in Cuddapah region deficient in sulphur content due to lesser concentration of sulphur.

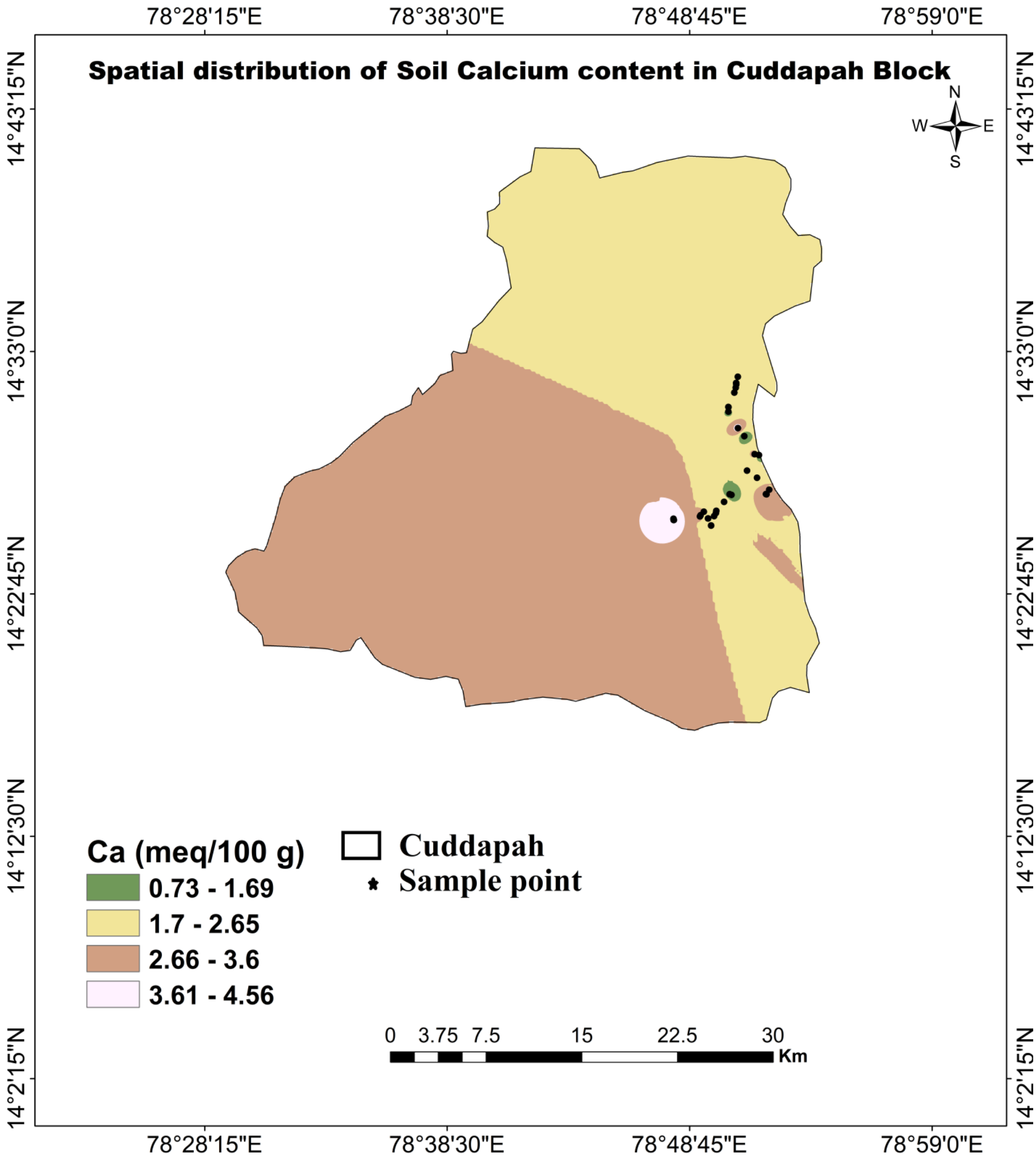
Table 4.1.3c: Classification of soil samples under different sulphur range

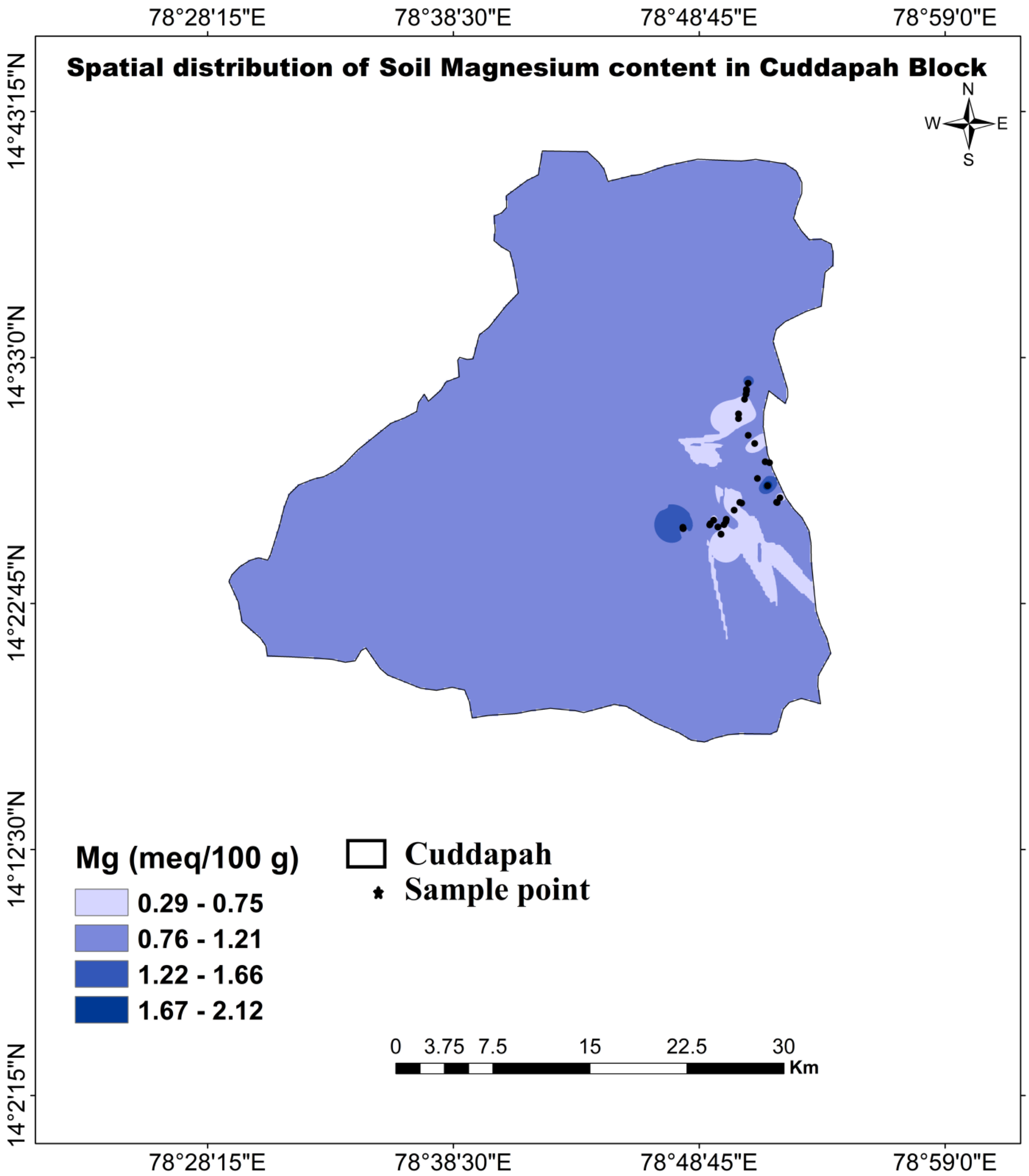
Classes	Limit	No. of samples	% of samples
Low	<10	40	100%
Medium	10-20	0	0%
High	>20	0	0%

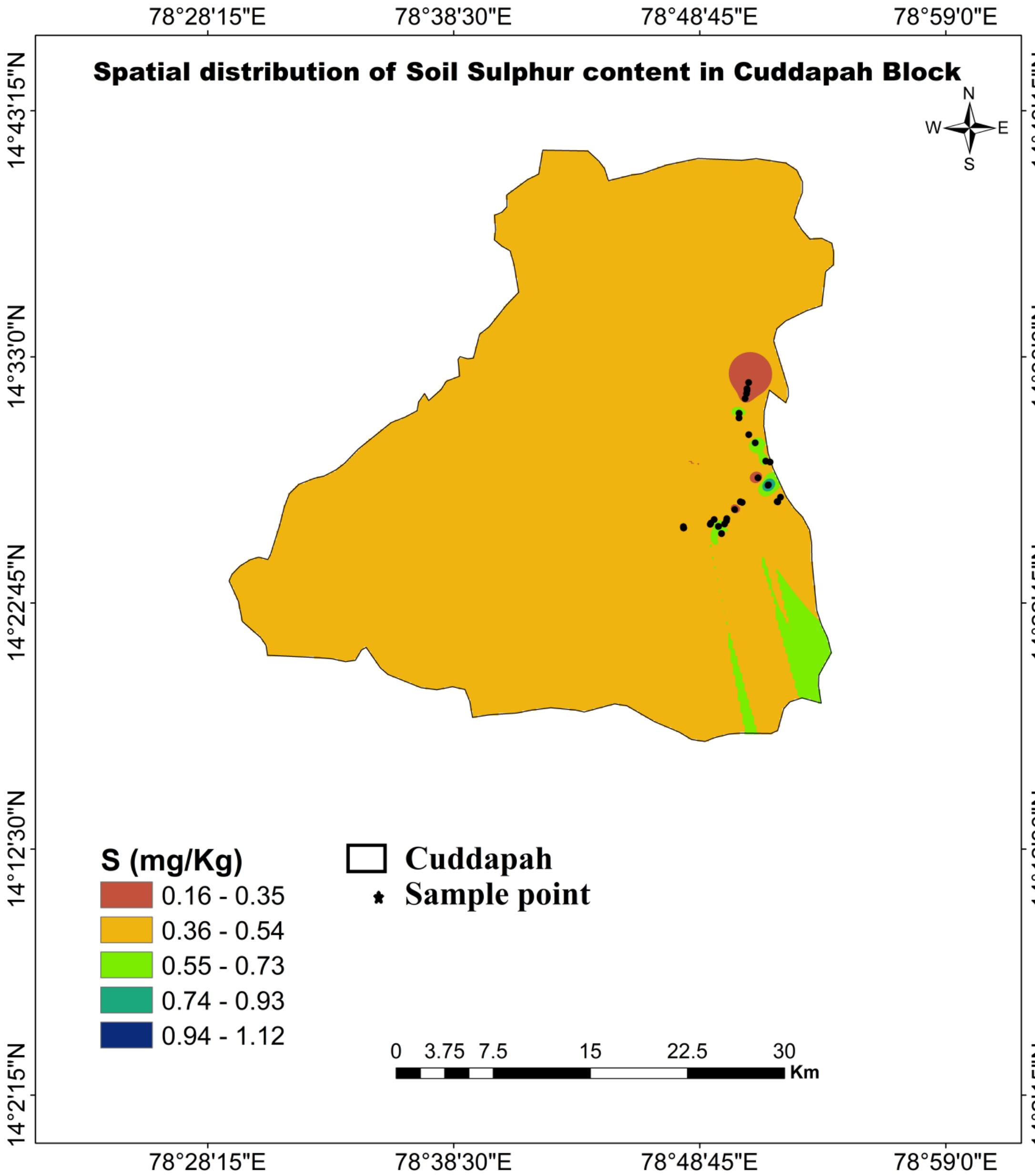
(Source: Kanwar, 1976)

Table 4.1.3: Statistical data on secondary parameters of soil

Soil parameters	Range	Mean	SD±	C.V(%)
Calcium	0.43-6.7	2.49	1.25	50.3
Magnesium	0.18-2.72	0.87	0.60	68.7
Sulphur	0.16-1.14	0.45	0.24	53.9


Spatial distribution of Soil Calcium content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
Ca (meq/100 g)
0.73 - 1.69
1.7 - 2.65
2.66 - 3.6
3.61 - 4.56
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km


Spatial distribution of Soil Magnesium content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
Mg (meq/100 g)
0.29 - 0.75
0.76 - 1.21
1.22 - 1.66
1.67 - 2.12
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km



Spatial distribution of Soil Sulphur content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
S
W
E
S (mg/Kg)
0.16 - 0.35
0.36 - 0.54
0.55 - 0.73
0.74 - 0.93
0.94 - 1.12
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km

4.1.4 Status of available micronutrients in the soil

The resulted data from the analysis of available micronutrients such as Iron (Fe), Copper (Cu), Manganese (Mn) and Zinc (Zn) in the soil are presented in the Table 4.1.4 and in Appendix 6.

Values of available iron content in the soil samples were observed to be in the range of 1-12.4 mg/kg with a mean value of 5.37 mg/kg whereas standard deviation and coefficient of variation of available iron have been recorded as 3.57 and 66.4%. The highest iron content was noticed in site 3 sample no:9 puttlampalli and the lowest iron content was noticed in site 7 sample no: 25 ukkaypalli. Out of total soil samples of Cuddapah block 25% of the samples were recognized as deficient in iron content, 55% of the samples were found in sufficient range and 20% of the samples were found in excess range. The observations were being in conformity with the findings of **Madhu and David (2017)** in soils of Jamuna paar region of Allahabad district in Uttarpradesh.

Table 4.1.4a: Classification of soil samples under different Iron range

Available Fe (mg/kg)	Limit	No. of samples	% of samples
Deficient	<2.5	10	25%
Sufficient	2.5-4.5	22	55%
Excess	>4.5	8	20%

Values of available copper content in the soil samples were observed to be in the range of 0.1-8.3 mg/kg with a mean value of 3.07 mg/kg whereas standard deviation and coefficient of variation of available copper have been recorded as 2.21 and 72.2%. The highest copper content was noticed in site 6 sample no: 21 chalamreddypalli and the lowest copper content was noticed in site 10 sample no: 39 subbanavaripalli and site 8 sample no: 32 apparajupalli. The results revealed that out of total soil samples 10% of the samples were found in excess range whereas 67.5% of the samples were found in excess range and 15% of the samples are deficient in copper content. Similar observations were reported by **Vikas D.Umare,** 2018 in soils of Chandrapur area , Maharashtra.

Table 4.1.4b: Classification of soil samples under different copper range

Available Cu (mg/kg)	Limit	No. of samples	% of samples
Deficient	<0.2	6	15%
Sufficient	0.2-5.0	30	75%
Excess	>5.0	4	10%

Values of available manganese content in the soil samples were observed to be in the range of 0.6-10.0 mg/kg with a mean value of 2.46 mg/kg whereas standard deviation and coefficient of variation of available manganese have been recorded as 1.96 and 80.03% respectively. The highest manganese content was noticed in site 6 sample no: 20 Jamalpalli and the lowest manganese content was noticed in site 9 sample no: 33 peddamusalreddypalli .The results revealed that 65% of the soil samples have shown deficient in manganese content, 22.5% of the samples are on sufficient range and 12.5% of the samples are in excess range. Similar results were observed with **Madhu and David (2017)** while studying soils of Jamuna paar region of Allahabad district in Uttarpradesh.

Table 4.1.4c: Classification of soil samples under different Manganese range

Available Mn(mg/kg)	Limit	No. of samples	% of samples
Deficient	<2.0	26	65%
Sufficient	2.0-4.0	9	22.5%
Excess	>4.0	5	12.5%

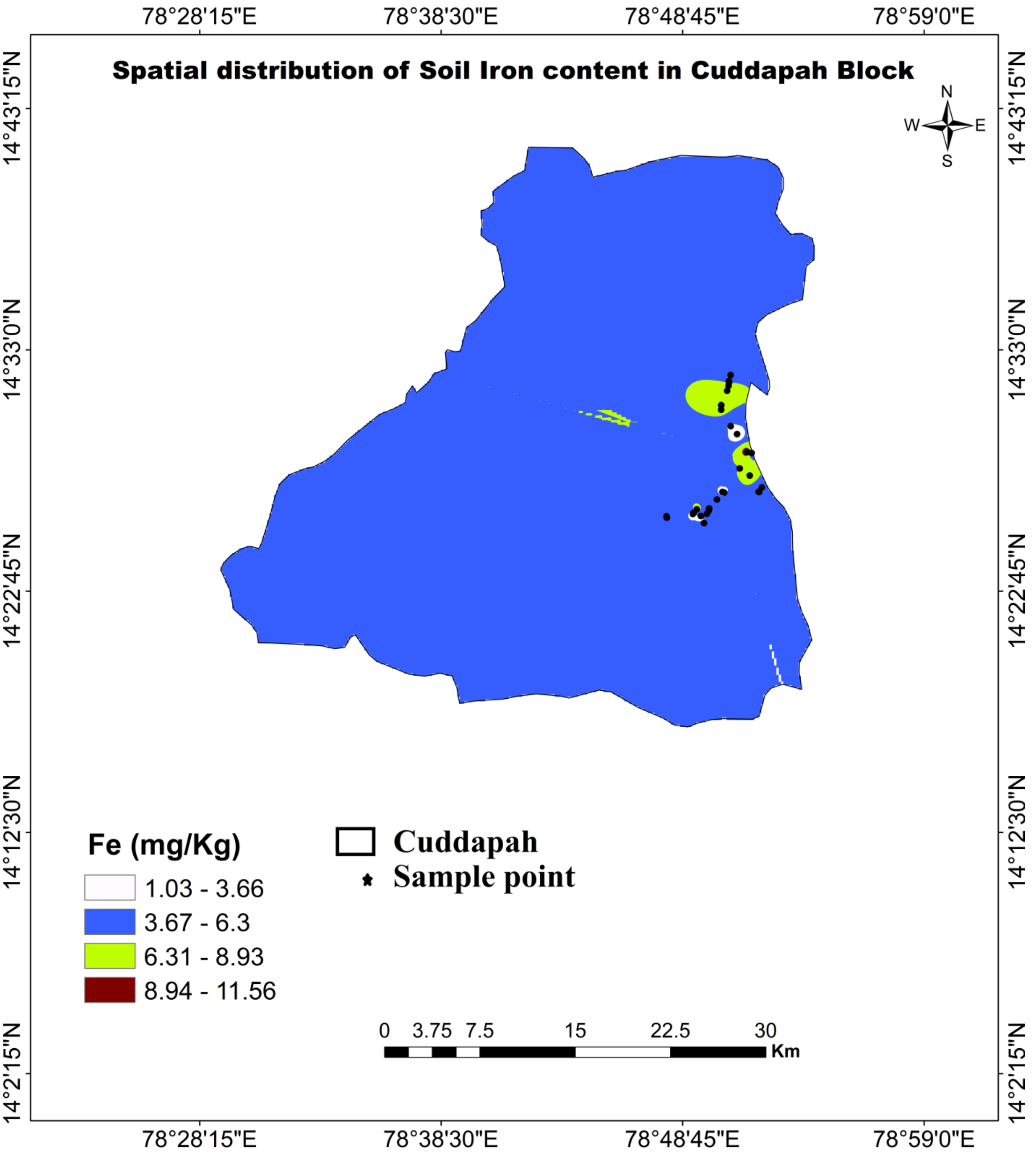
Values of available zinc content in the soil samples were observed to be in the range of 0.1-4.5 mg/kg with a mean value of 1.08 mg/kg whereas standard deviation and coefficient of variation of available zinc have been recorded as 1.14 and 100.4 %. The highest zinc content was noticed in site 6 sample no: 21 chalamareddypalli and the lowest zinc content was noticed in site 3 sample no: 11 puttlampalli. Out of total soil samples 55% have shown deficient in zinc , 32.5% of the samples were found in sufficient range and 12.5% of the samples were found in excess range. The present findings are in conformity with the observations done by **Vikas D.Umare, 2018** who studied the soils of Chandrapur area, Maharashtra.

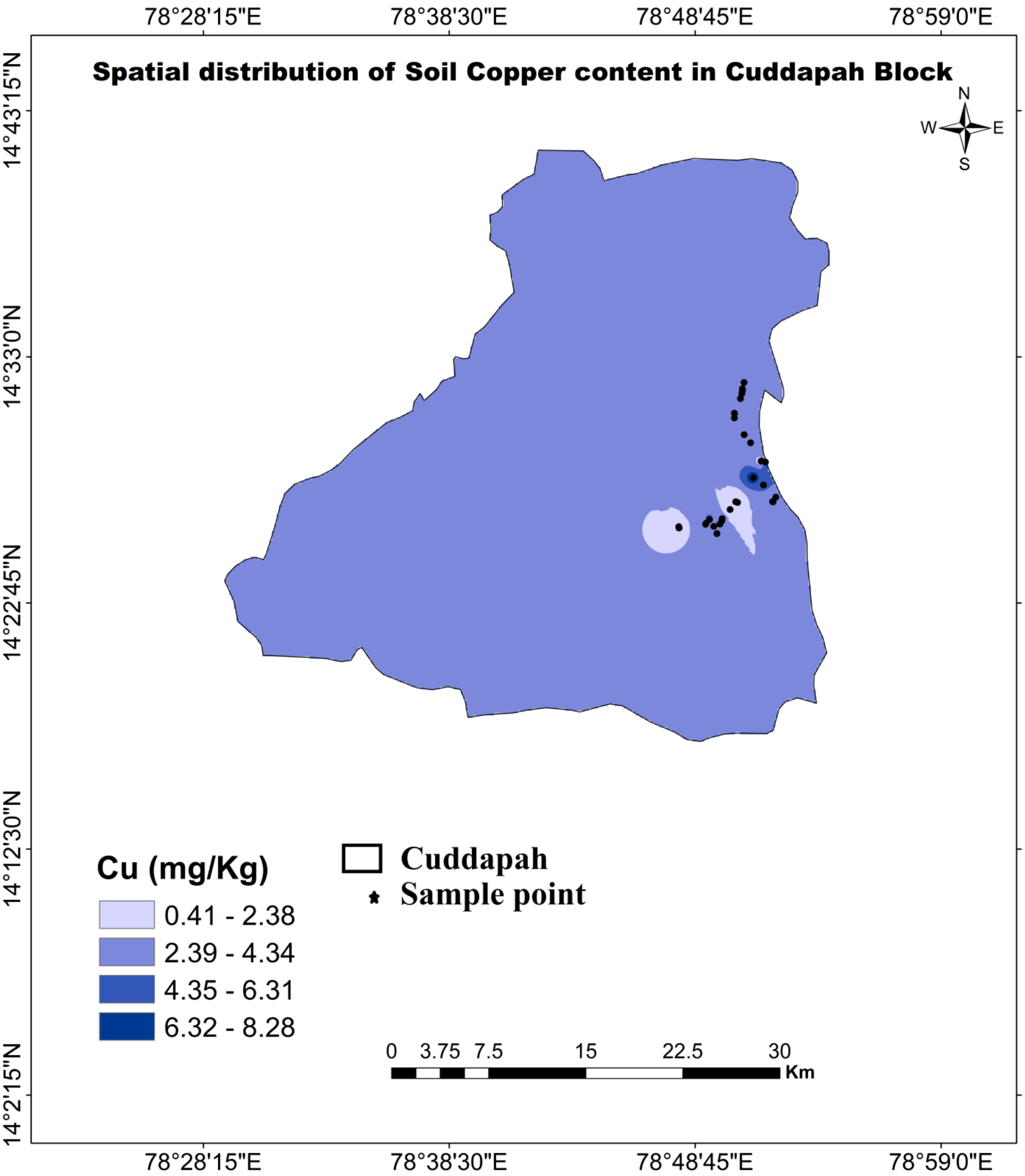
Table 4.1.4d: Classification of soil samples under different Zinc range

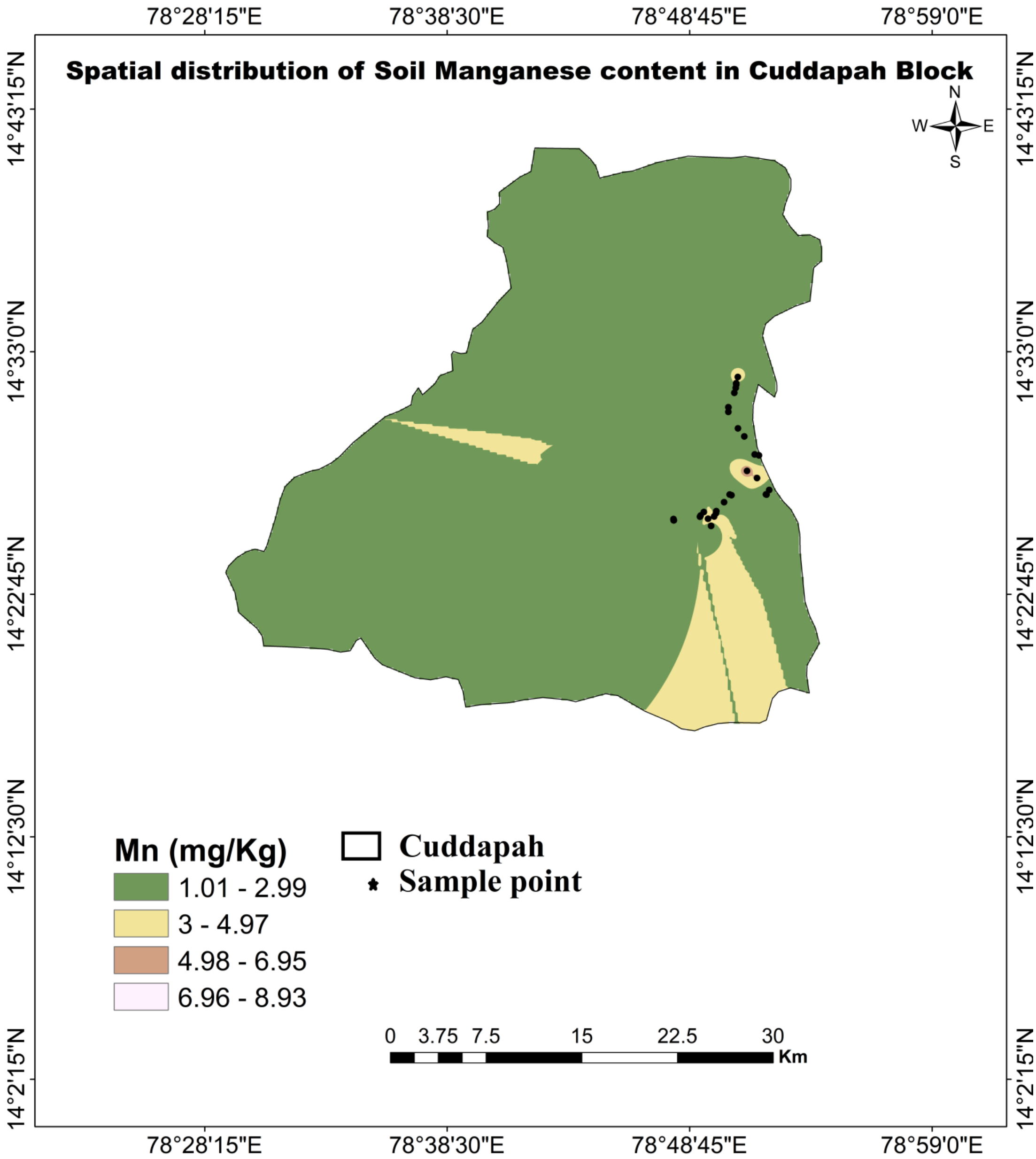
Available Zn (mg/kg)	Limit	No. of samples	% of samples
Deficient	<0.6	22	55%
Sufficient	0.6-1.5	13	32.5%
Excess	>1.5	5	12.5%

Table 4.1.4 Statistical data on available micronutrients of soil

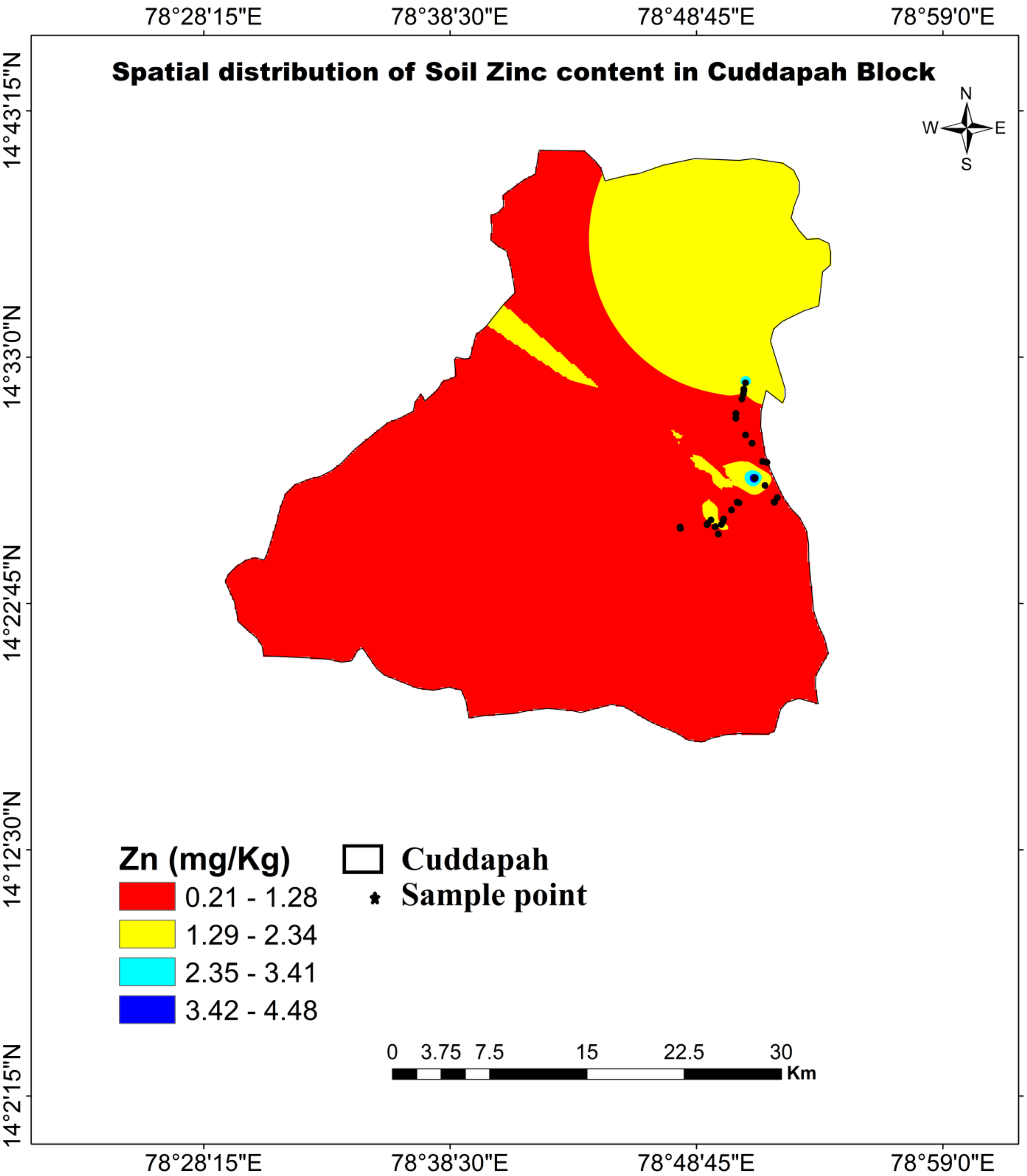
Soil parameters (mg/kg)	Range	Mean	S.D±	C.V(%)
Available Iron	1.0-12.4	5.37	3.57	66.4
Available Copper	0.1-8.3	3.07	2.21	72.2
Available Manganese	0.6-10.0	2.46	1.96	80.03
Available Zinc	0.1-4.5	1.08	1.14	105.4


Spatial distribution of Soil Iron content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
Fe (mg/Kg)
1.03 - 3.66
3.67 - 6.3
6.31 - 8.93
8.94 - 11.56
Cuddapah
Sample point
0
3.75
7.5
15
22.5
30
Km


Spatial distribution of Soil Copper content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
Cu (mg/Kg)
0.41 - 2.38
2.39 - 4.34
4.35 - 6.31
6.32 - 8.28
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km



Spatial distribution of Soil Manganese content in Cuddapah Block
78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
N
W
E
S
Mn (mg/Kg)
1.01 - 2.99
3 - 4.97
4.98 - 6.95
6.96 - 8.93
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km


78°28'15"E
78°38'30"E
78°48'45"E
78°59'0"E
14°43'15"N
14°33'0"N
14°22'45"N
14°12'30"N
14°2'15"N
Spatial distribution of Soil Zinc content in Cuddapah Block
N
W
E
S
Zn (mg/Kg)
0.21 - 1.28
1.29 - 2.34
2.35 - 3.41
3.42 - 4.48
Cuddapah
Sample point
0 3.75 7.5 15 22.5 30
Km

4.1.5 Soil Nutrient Index

In order to compare the fertility levels of soil from one area to the other area it is necessary to procure a single value for each and every nutrient. Soil Nutrient Index is nothing but a measure of capacity of soil to supply nutrients to plants. The nutrient index approach was introduced by **Parker *et al.* 1951** and it has been taken up and altered by several researchers and National or International organizations viz., ICAR-NBSS & LUP, Food and Agricultural Organization (FAO), Ministry of Agriculture etc. This index is utilized for the assessment of soil fertility status based on the values obtained for the collected samples and fertility rating has been given according to the categories i.e., low, medium and high. The nutrient index values for soils in Cuddapah block for different fertility parameters are given in Table 4.1.5.

Table 4.1.5: Nutrient Index values of Cuddapah block in YSR district of Andhra Pradesh

S.No.	Available Nutrients	Nutrient index values	Category
1	Organic carbon	1.92	Medium
2	Nitrogen	1.52	Low
3	Phosphorous	1.95	Medium
4	Potassium	2.45	High
5	Sulphur	1.00	Low
6	Iron	1.95	Medium
7	Copper	1.95	Medium
8	Manganese	1.47	Low
9	Zinc	1.57	Low

4.1.6 The study on correlation matrix between physico-chemical properties of soil in different villages from Cuddapah block of YSR district, Andhra Pradesh.

The resulted data on correlation matrix between physico-chemical properties of soil in different villages from Cuddapah block of YSR district, Andhra Pradesh were presented in Table 4.1.6.

The bulk density of the soil is negatively non- significantly correlated with porosity (r = -0.606), water holding capacity (r = -0.081), pH (r = -0.002), EC (r = -0.016), organic carbon (r = -0.218), nitrogen (r = -0.146), potassium (r = -0.111), calcium (r = 0.082) and positively non- significantly correlated with particle density (r = 0.204), phosphorous (r = 0.069), magnesium (r = 0.074), iron (r = 0.115), copper (r = 0.074), zinc (r=0.018) and manganese (r = 0.254) whereas positively significantly correlated with sulphur (r = 0.327).

The particle density of the soil is positively non-significantly correlated with porosity (r = 0.654), pH (r = 0.082), potassium (r = 0.158), calcium (r = 0.101), iron (r = 0.098), manganese (r = 0.147), Zinc (r = 0.005) and negatively non- significantly correlated with water holding capacity (r = -0.122), EC (r = -0.231), organic carbon (r = -0.138), nitrogen (r = -0.087), phosphorous (r = -0.055), magnesium (r = -0.001), sulphur (r = -0.108) and copper (r = -0.04).

The porosity of the soil is negatively non- significantly correlated with water holding capacity (r = -0.031), EC (r = -0.186), phosphorous (r = -0.111), magnesium (r = -0.072), iron (r = -0.019), zinc (r = -0.014), manganese (r = -0.082) and negatively significantly correlated with sulphur (r = -0.345), copper (r = -0.098) and positively non- significantly correlated with pH (r=0.084), organic carbon (r = 0.053), nitrogen (r = 0.031), potassium (r = 0.206) and calcium (r = 0.143).

The water holding capacity of the soil is positively non- significantly correlated with EC (r = 0.085), organic carbon (r = 0.094), nitrogen (r = 0.021), phosphorous (r = 0.116), iron (r = 0.179), and positively significantly correlated with sulphur (r = 0.363) whereas negatively non- significantly correlated with pH (r = -

0.129), potassium (r = -0.170), calcium (r = -0.070), magnesium (r = -0.018) , copper (r = -0.074), manganese (r = -0.005) and zinc (r = -0.098).

The pH of the soil is negatively non-significantly correlated with EC (r = 0.037), organic carbon (r = -0.194), nitrogen (r = -0.157), phosphorous (r = -0.902), magnesium (r = -0.001), sulphur (r = -0.015), zinc (r = -0.647) and negatively highly significantly correlated with iron (r = -0.480), manganese (r = -0.467) and copper (r = -0.509). The electrical conductivity of the soil is positively significantly correlated with organic carbon (r = 0.322), nitrogen (r = 0.423), potassium (r = 0.373), manganese (r = 0.08) and positively non- significantly correlated with phosphorous (r = 0.02), magnesium (r = 0.261), sulphur (r = 0.267), zinc (r = 0.008) and negatively non- significantly correlated with calcium (r = -0.026), iron (r = -0.085) and copper (r = -0.187).

The organic carbon content of the soil is positively non- significantly correlated with nitrogen (r = 0.754), phosphorus (r = 0.193), potassium (r = 0.219), copper (r = 0.102), and positively significantly correlated with sulphur(r=0.355) and manganese (r = 0.02), negatively non- significantly correlated with iron (r = -0.173), zinc (r = -0.059) while negatively significantly correlated with calcium (r = -0.362).

The primary macronutrients of the soil i.e., nitrogen content of the soil is positively non- significantly correlated with phosphorous (r = 0.118), magnesium (r = 0.172), copper (r = 0.151) and positively highly significantly correlated with potassium (r = 0.436) and manganese (r = 0.202) and negatively non- significantly correlated with iron (r = -0.09), zinc (r = -0.04) and negatively highly significantly correlated with calcium (r = -0.427). The phosphorous content of the soil is negatively non- significantly correlated with potassium (r = -0.131), calcium (r = -0.002), magnesium (r = -0.053) and positively non- significantly correlated with sulphur (r = 0.058) and positively significantly correlated with manganese (r = 0.476) , iron (r = 0.472), copper (r = 0.393) and zinc (r = 0.639). The potassium content of the soil is negatively non- significantly correlated with calcium (r = -0.074), iron (r = -0.024), copper (r = -0.123), zinc (r = -0.042) and positively non-significantly correlated with magnesium (r = 0.168), sulphur (r = 0.058), manganese (r = 0.001).

The secondary macronutrients of the soil i.e., calcium content of the soil is positively non- significantly correlated with magnesium(r = 0.137), sulphur (r = 0.028), iron (r = 0.109) while negatively non- significantly correlated with copper (r = -0.300) , zinc (r = -0.06) and mangan0ese (r = -0.162). The magnesium content of the soil is positively non- significantly correlated with sulphur (r = 0.218), iron (r = 0.014), manganese (r = 0.098) and negatively non-significantly correlated with zinc (r = -0.036) and copper (r = -0.017). The sulphur content of the soil is positively non-significantly correlated with iron (r = 0.084), manganese (r = 0.115) whereas negatively non- significantly correlated with copper (r = -0.123) and zinc (r = -0.310).

The available micronutrients of the soil i.e., iron content of the soil is positively non- significantly correlated with copper (r = 0.151), manganese (r = 0.198) and zinc (r = 0.254). The copper content of the soil is positively non- significantly correlated with manganese (r = 0..425) and highly significantly correlated with zinc (r = 0.458). The manganese content of the soil is positively non- significantly correlated with zinc (r = 0.611

Table 4.1.6: Correlation between physico-chemical properties of soil of Cuddapah block in YSR district of Andhra Pradesh

	BD	*PD*	*POROSITY*	*WHC*	*pH*	*EC*	*OC%*	*N*	*P*	*K*	*Ca*	*Mg*	*S*	*Fe*	*Cu*	*Mn*	*Zn*
BD	1																
PD	0.204	1															
POROSITY	-0.606	0.654	1														
WHC	-0.081	-0.123	-0.031	1													
pH	-0.002	0.082	0.084	-0.130	1												
EC	-0.016	-0.232	-0.186	0.085	-0.037	1											
OC%	-0.218	-0.139	0.053	0.094	-0.194	0.322*	1										
N	-0.146	-0.087	0.031	0.021	-0.157	0.423**	0.754	1									
P	0.069	-0.055	-0.111	0.116	-0.902	0.020	0.193	0.118	1								
K	-0.111	0.158	0.206	-0.170	0.008	0.373**	0.219	0.436**	-0.131	1							
Ca	-0.082	0.101	0.143	-0.070	0.135	-0.026	-0.362*	-0.427**	-0.002	-0.074	1						
Mg	0.074	-0.001	-0.072	-0.018	-0.001	0.261	-0.108	0.172	-0.053	0.168	0.137	1					
S	0.327*	-0.108	-0.345*	0.363*	-0.015	0.267	0.355*	0.297	0.058	0.058	0.028	0.218	1				
Fe	0.115	0.098	-0.019	0.179	-0.480**	-0.085	-0.173	-0.090	0.472*	-0.024	0.109	0.014	0.084	1			
Cu	0.074	-0.040	-0.098	-0.074	-0.509**	-0.187	0.102	0.151	0.393*	-0.123	-0.300	-0.017	-0.123	0.151	1		
Mn	0.254	0.147	-0.082	-0.005	-0.467	0.083**	0.020*	0.202**	0.476*	0.001	-0.162	0.098	0.115	0.198	0.425	1	
Zn	0.023	0.005	-0.014	-0.098	-0.647**	0.008	-0.059	-0.040	0.639*	-0.042	-0.060	-0.036	-0.310	0.254	0.458**	0.611	1

Note: (*) represents significant at 0.05 level and (**) represents significant at 0.01 level.

4.2 Analysis of water parameters

4.2.1 The chemical parameters of water

The obtained data on chemical parameters of ground water is given in Table-4.2 and in Appendix 8.

Water pH

The range of pH in the water samples were varied from 7.0-8.3 with a mean value of 7.6 whereas standard deviation and coefficient of variation of pH have been recorded as 0.35 and 4.66 %. Site 5 sample no: 18 jamalpalli and site 9 sample no: 34 peddamusalreddypalli have reported highest pH value (8.3) whereas site 7 sample no: 27 ukkaypalli has reported lowest pH (7.0). The results declared that all the water samples (100%) of Cuddapah block are neutral to alkaline in nature and are suitable for irrigation purposes. Higher pH is server to the crops **(Ayers and Westcot, 1985)** and decreases the efficacy of some nitrogenous fertilizers through irrigation **(Bryan *et al.* 2007).** Similar results were reported by **Gummadi *et al.* (2015)** in his investigation carried out on irrigation water in Coastal Andhra Pradesh.

Table 4.2.1a: Classification of water samples under different pH range

Classes	Limit	No. of samples	% of samples
Suitable	6.5-8.4	40	100%
Moderately suitable	0-6.4	0	0%
Not suitable	>8.5	0	0%

(Source: WHO)

Electrical conductivity

The range of Electrical conductivity in the water samples were varied from 0.279 - 3.642 dS/m with a mean value of 1.425 dS/m whereas standard deviation and coefficient of variation of EC have been recorded as 0.81 and 57.5%. Site 9 sample no: 33 peddamusalreddypalli has reported highest (3.642 dS/m) EC while site 1 sample no: 2 mamillapalli has reported lowest (0.279 dS/m) EC. Out of total water samples 10% of the samples were found in suitability range for irrigation, 82.5% of the samples were found in moderately suitable range for irrigation and 7.5% of the samples are not suitable for irrigation. This clearly states that quality of water in terms of EC in Cuddapah town are moderate range for the use in irrigation. Higher concentration of EC indicates that high amount of total dissolved salts which causes water to lose its portability and bring down the solubility of oxygen in water **(Kumar *et. al.* 2011).**

Table 4.2.1b: Classification of water samples under different EC range

Classes	Limit(dS/m)	No. of samples	% of samples
Suitable	0.7	4	10%
Moderately suitable	0.7-3.0	33	82.5%
Not suitable	>3.0	3	7.5%

(Source: FAO.org)

4.2.2 Status of Anions in ground water (Cl^-, CO_3^{2-} and HCO_3^-)

The data resulted from the analysis of major anions such as chloride, Carbonate and bicarbonate of the groundwater from various villages of Cuddapah block of Y.S.R district, Andhra Pradesh are given in the table 4.2 and in Appendix 9.

Chloride

The range of Chloride concentration in the water samples were varied from 1.6 to 28.4 Meq/lit with 6.97 as a mean value. The SD and CV values of chloride have been observed as 5.53 and 79.2%. Site 6 sample no: 23 chalamareddypalli has showed highest chloride concentration while site 1 sample no: 2 mamillpalli has showed lowest chloride concentration. The results revealed that 22.5% of the samples were found under suitable range , 65% of the samples were found under moderately suitable range and 12.5% of the samples were found under not suitable for irrigation which conclude that the water samples from Cuddapah block are in moderate range for its use in irrigation.

Table 4.2.2a: Classification of water samples under different chloride range

Classes	Limit	No. of samples	% of samples
Suitable	<4	9	22.5%
Moderately suitable	4-10	26	65%
Not suitable	>10	5	12.5%

(Source: FAO.org)

Carbonate and Bicarbonate

The current investigation has shown that the ground water collected from different villages in Cuddapah block are completely free from Carbonate concentration. The range of bicarbonate in the water samples were varied from 1.6-5.2 Meq/lit with 3.17 Meq/lit as a mean value. The SD and CV values of bicarbonate have been observed as 0.98 and 30.9%. Site 9 sample no: 35 peddamusalreddypalli has showed highest bicarbonate concentration whereas site site 10 sample no: 38 subbanavaripalli has showed lowest bicarbonate concentration. It was found that all the water samples (100%) of Cuddapah block are moderately suitable in terms of bicarbonate concentration. According to **Ayer and Westcot, 1985** carbonate concentration with more than 0.1 Meq/lit and bicarbonate concentration with more than 10 Meq/lit are not recommended for irrigation purpose usually.

Table 4.2.2b: Classification of water samples under different alkalinity range

Classes	Limit	No. of samples	% of samples
Suitable	1.25	0	0%
Moderately suitable	1.25-8.50	40	100%
Not suitable	>8.50	0	0%

(Source: FAO.org)

4.2.3 Status of cations in groundwater

The data resulted from the analysis of cationic status such as Calcium+ Magnesium, Sodium and Potassium are given in the Table- 4.2 and in Appendix 10.

Calcium and Magnesium

The range of Calcium and Magnesium in the water samples were varied from 8.4 to 46.2 Meq/lit with 23.33 Meq/lit as a mean value. The SD and CV values of calcium and magnesium have been observed as 10.32 and 44.2%. According to the results Site 8 sample no:31 apparajupalli has noticed highest (46.2 Meq/L) calcium plus magnesium concentration while site 5 sample no: 20 jamalpalli has noticed lowest (8.4 Meq/L) concentration calcium plus magnesium . As per the guidelines prescribed by ICMR, 1975 highest desirable limit for total hardness is 6.0 Meq/L . So according to the guideline it was found that all the water samples of Cuddapah block are not suitable for its usage in irrigation in terms of hardness.

Sodium

The range of Sodium content in the water samples were varied from 0.56 to 3.87 Meq/lit with 1.83 Meq/lit as its mean value. The SD and CV of the sodium have been observed as 0.78 and 42.6%. Sample no: 14 site 4 nanapalli has reported lowest sodium concentration (0.56 Meq/L) while sample no: 11 site 3 puttlampalli has reported highest sodium concentration (3.87 Meq/L). As per the results it was found that 92.5% of the water samples are in suitable range for irrigation purpose and 7.5% of the samples are under moderately suitable range for irrigation.

Table 4.2.3a: Classification of water samples under different sodium range

Classes	Limit	No. of samples	% of samples
Suitable	<3	37	92.5%
Moderately suitable	3-9	3	7.5%
Not suitable	>9	0	0%

(Source: FAO.org)

Potassium

The range of Potassium content in the water samples were varied from 0.02 – 0.79 with 0.23 Meq/lit as its mean value . The SD and CV values of Potassium have been observed as 0.193 and 80.6%. Sample no: 8 site 2 modimedapalli has reported highest potassium while sample no: 9 and sample no:12 in site 3 puttlampalli has reported lowest potassium content.

4.2.4 Irrigation Water Quality Index

The resulted data on irrigation water quality index such as is presented in the Table- 4.2 and in Appendix 11.

In order to obtain the quality status of ground water used for irrigation purpose of different villages in Cuddapah block, an attempt has been made to promote a model on Irrigation Water Quality Index (IWQI). Different irrigation quality indices such as Sodium adsorption ratio (SAR), Soluble sodium percentage (SSP), Residual Sodium carbonate (RSC), Permeability Index (PI) and Kelly's Ratio (KR) were considered to evaluate the quality of groundwater for irrigation.

The Irrigation water quality index of samples are ranged from 86.7 to 504.6 with a mean value of 236.7. The SD and CV values of the samples have been recorded as 88.9 and 37.5% respectively. The highest range was observed in site 7 sample no: 27 ukkaypalli and the lowest range was observed in site 1 sample no: 2 mamillapalli. Out of total number of water samples only one sample (2.5%) is recognized to be good for irrigation , 37.5% of the samples were found in poor range for irrigation, 37.5% of the samples were found as very poor range for irrigation and 22.5% of the samples are unsuitable for the irrigation. This is due to the presence of high concentration of calcium and magnesium i.e, total hardness causes high water quality index in water.

Table 4.2.4a: Classification of water samples under different IWQI range

WQI	Water quality status	No. of samples	% of samples
<50	Excellent	0	0%
50-100	Good	1	2.5%
100-200	Poor	15	37.5%
200-300	Very poor	15	37.5%
>300	Unsuitable	9	22.5%

(Source: Anbazaghan, 2014)

Sodium adsorption ratio

The values of sodium adsorption ratio were observed to be in the range of 0.17-1.44 with an average value of 0.58. The SD and CV values of SAR have been recorded as 0.30 and 52.6%. The highest value (1.44 Meq/L) of SAR was noticed in site 1 sample no: 4 mamillapalli and the lowest value (0.17 Meq/L) of SAR was noticed in site 3 sample no: 11 puttlampalli .The results declared that 100% of the samples are within permissible limit and belongs to class S1 which indicates no sodium hazard therefore all the ground water samples are in suitable range for irrigation purpose. The present findings are being in conformity with the observations made by Nag and Das (2014) in West Bengal.

Table 4.2.4b: Classification of water samples under different sodium adsorption ratio range

Classes	Limit	No. of samples	% of samples
S_1 (very low sodium hazard)	0-3	40	100%
S_2 (low sodium hazard)	3-6	0	0%
S_3 (medium sodium hazard)	6-12	0	0%
S_4 (high sodium hazard)	12-20	0	0%
S_5 (very high sodium hazard)	20-40	0	0%

(Source: FAO.org)

Soluble sodium percentage

The values of soluble sodium percentage were observed to be in the range of 14.8-68.1 with an average value of 35.4. The SD and CV values of SSP have been observed as 14.1 and 39.8%. The highest value (68.1%) of SSP was reported in site 1 sample no: 2 mamillapalli whereas lowest value (14.8) of SSP was reported in site 7 sample no: 27 ukkaypalli . The results revealed that out of total water samples in Cuddapah block 85% of the samples are in suitable range and good for irrigation purpose and 15% of the samples are not suitable for irrigation.

Table 4.2.4c: Classification of water samples under different soluble sodium percentage range

Classes	Limit	No. of samples	% of samples
Good	<50	34	85%
Not suitable	>50	6	15%

(Source: USDA, 1954)

Permeability Index

The values of permeability index were observed to be in the range of 7.55-37.88 with an average value of 16.8. The SD and CV values of permeability index have been recorded as 8.27 and 49.1 %. The highest value (37.88) of PI was found in site 5 sample no: 20 jamalpalli and the lowest value (7.55%) was found in site 8 sample no: 32 apparajupalli. Out of total water samples 85% of the samples are within moderate permissible limit and 15% of the samples are not under permissible limit and recognized as unsuitable for the irrigation.

Table 4.2.4d: Classification of water samples under different permeability index range

Classes	Limit	No. of samples	% of samples
Excellent	>75	0	0%
Good	25-75	34	85%
Not suitable	<25	6	15%

(Source: Doneen’s, 1964)

Kelly's Ratio

The values of kelly's ratio were observed to be in the range of 0.02-0.30 with an average value of 0.09. The SD and CV values of Kelly's ratio have been recorded as 0.07 and 72.2%. The highest value (0.30) of KR was noticed in site 1 sample no: 4 mamillapalli and the lowest value (0.02) of KR was noticed in site 3 sample no:11 puttlampalli. It was found that 100% of the water samples are within permissible range and fit for irrigation purpose.

Table 4.2.4e: Classification of water samples under different Kelly's ratio range

Classes	Limit	No. of sample	% of samples
Good	<1.0	40	100%
Not suitable	>1.0	0	0%

(Source: Karanth, 1987)

Residual sodium carbonate

The values of Residual sodium carbonate in the water samples were observed to be in the range of -44 to -5.2 with an average value of -20.16. The SD and CV values of RSC have been recorded as 10.4 and -51.5%. In the collected ground water samples all the samples have shown negative value of RSC specifying low risk of sodium accumulation due to calcium and magnesium offsetting levels. Similar results were observed with Kumar *et al.* (2015) in Lahore block while studying about water quality. According to the results obtained it was stated that 100% of the samples falls under low hazard category and are in permissible range.

Table 4.2.4f: Classification of water samples under different Residual sodium carbonate range

Classes	Limit	No. of samples	% of samples
Low hazard	<1.25	40	100%
Medium hazard	1.25-2.25	0	0%
High hazard	>2.25	0	0%

(Source: Doneen's, 1964)

Table 4.2: Statistical data of water quality parameters

Parameters	Mean	Range	S.D±	C.V(%)
pH	7.6	7.0 – 8.3	0.35	4.66
EC	1.425	0.279 – 3.642	0.81	57.5
$Ca^{2+} + Mg^{2+}$	23.3	8.4 – 46.2	10.3	44.2
Ca^{2+}	13.1	5.4 – 30	6.89	52.4
Na^{+}	1.83	0.56 – 3.87	0.78	42.6
K^{+}	0.23	0.02 – 0.79	0.19	80.6
Cl^{-}	6.97	1.6 – 28.4	5.53	79.2
HCO_3	3.17	1.6-5.2	0.98	30.9
SAR	0.58	0.17 – 1.44	0.30	52.6
SSP	35.4	14.8 – 68.1	14.1	39.8
PI	16.8	7.55 – 37.8	8.27	49.1
KR	0.09	0.02 – 0.30	0.07	72.2
RSC	-20.1	-44 - -5.2	10.4	-51.5
IWQI	236.7	86.7 – 504.6	88.9	37.5

4.2.5 Study on correlation matrix between various chemical properties of ground water of different villages from Cuddapah block in YSR district, Andhra Pradesh.

The resulted data on correlation matrix between various chemical properties of water of different villages from Cuddapah block in YSR district, Andhra Pradesh were presented in Table: 4.2.5a.

The pH of the water is positively non-significantly correlated with EC (r = 0.038), calcium (r = 0.010), bicarbonate (r = 0.086), calcium + magnesium (r = 0.006), soluble sodium percentage (r = 0.051), residual sodium bicarbonate (r = 0.002) and negatively non significantly correlated with sodium (r = -0.207), potassium (r = -0.049), magnesium (r = -0.001), chloride (r = -0.168), sodium adsorption ratio (r = -0.156), permeability index (r = -0.107) and Kelly's ratio (r = -0.122). The EC of the water is positively non-significantly correlated with potassium (r = 0.059), magnesium (r = 0.051), bicarbonate (r = 0.018), sodium adsorption ratio (r = 0.042) and positively highly significantly correlated with calcium (r = 0.469),chloride (r = 0.528) positively significantly calcium+magnesium (r = 0.344) and negatively non-significantly correlated with permeability imdex (r = -0.245), kelly's ratio (r = -0.126), negatively highly significantly correlated with soluble sodium percentage (r = -0.388) and negatively significantly correlated with RSC (r = -0.340). The sodium content of the water is positively non-significantly correlated with potassium (r = 0.035), calcium (r = 0.200), calcium+magnesium (r = 0.015), sodium adsorption ratio (r = 0.859), kelly's ratio (r = 0.673), soluble sodium percentage(r = 0.015) and negatively non-significantly correlated with bicarbonate (r = -0.222), RSC(r = -0.036) and positively highly significantly correlated with chloride (r = 0.529) and permeability index (r = 0.428). The potassium content of water is positively non-significantly correlated with calcium (r = 0.211), magnesium (r = 0.018), bicarbonate (r = 0.133), chloride (r = 0.066), calcium+ magnesium (r = 0.151) and negatively non-significantly correlated with sodium adsorption ratio (r = -0.032), permeability index (r = -0.044), Kelly's ratio (r = -0.058), soluble sodium percentage (r = -0.107) and RSC (r = -0.138). The calcium content of water is positively non-significantly correlated with magnesium (r = 0.224), calcium+ magnesium (r = 0.804) and positively highly significantly correlated with chloride (r = 0.432) and negatively non-significantly correlated with bicarbonate (r = -0.135), sodium adsorption ratio (r = -0.217), permeability index (r=-0.561), Kelly's ratio (r = -0.398), soluble sodium percentage (r = -0.686) and RSC (r = -0.811). The magnesium content of the water is positively non-significantly correlated with bicarbonate (r = 0.092), chloride (r = 0.233), calcium+ magnesium (r = 0.759) and negitively highly significantly correlated with Sodium adsorption ratio(r = -0.512) and negatively non-significantly correlated with permeability index (r = -0.704), Kelly's ratio(r=-0.609), soluble sodium percentage (r = -0.758) and RSC (r = -0.745). The calcium+ magnesium content of the water is negatively non-significantly correlated with bicarbonate (r = -0.034), permeability index (r = -0.804), Kelly's ratio (r = -0.637), soluble sodium percentage (r = -0.920) and RSC (r = -0.996) and positively highly significantly correlated with chloride (r = 0.430) and negatively highly significantly correlated with sodium adsorption ratio (r = -0.457). The bicarbonate content of the water is negatively non-significantly correlated with chloride (r = -0.060), sodium adsorption ratio (r = -0.161), Kelly's ratio (r = -0.096) and positively non- significantly correlated with permeability index (r = 0.116), soluble sodium percentage (r = 0.077) and RSC (r = 0.128). The chloride content of the water is positively non- significantly correlated with sodium adsorption ratio (r = 0.186) and negatively non- significantly correlated with permeability index (r = -0.184), Kelly's ratio (r = -0.026) and negatively significantly correlated with soluble sodium percentage (r = -0.399) and RSC (r = -0.432). The sodium adsorption ratio of water is positively non- significantly correlated with permeability index (r = 0.810), Kelly's ratio (r = 0.954) and positively significantly correlated with soluble sodium percentage (r = 0.488) and RSC (r = 0.438). The permeability index of water is positively non- significantly correlated with Kelly's ratio (r = 0.930), soluble sodium percentage (r = 0.880) and RSC (r = 0.809). The Kelly's ratio of water is positively non- significantly correlated with soluble sodium percentage (r = 0.696) and RSC (r = 0.623). The soluble sodium percentage of water is positively non- significantly correlated with RSC (r = 0.921)

Table 4.2.5: Correlation between water quality parameters of Cuddapah block in YSR district of Andhra Pradesh.

	pH	*EC*	*Na*	*K*	*Ca*	*Mg*	*Ca+Mg*	*HCO3*	*Cl*	*SAR*	*PI*	*KR*	*SSP*	*RSC*
pH	1													
EC	0.038	1												
Na	-0.207	0.307*	1											
K	-0.049	0.059	0.035	1										
Ca	0.010	0.469**	0.200	0.211	1									
Mg	-0.001	0.051	-0.193	0.018	0.224	1								
Ca+Mg	0.006	0.344*	0.015	0.151	0.804	0.759	1							
HCO3	0.086	0.018	-0.222	0.133	-0.135	0.092	-0.034	1						
Cl	-0.168	0.528**	0.529**	0.066	0.432**	0.233	0.430**	-0.060	1					
SAR	-0.156	0.042	0.859	-0.032	-0.217	-0.512**	-0.457**	-0.161	0.186	1				
PI	-0.107	-0.245	0.428**	-0.044	-0.561	-0.704	-0.804	0.116	-0.184	0.810	1			
KR	-0.122	-0.126	0.673	-0.058	-0.398	-0.609	-0.637	-0.096	-0.026	0.954	0.930	1		
SSP	0.051	-0.388**	0.015	-0.107	-0.686	-0.758	-0.920	0.077	-0.399**	0.488**	0.880	0.696	1	
RSC	0.002	-0.340*	-0.036	-0.138	-0.811	-0.745	-0.996	0.128	-0.432**	0.438**	0.809	0.623	0.921	1

Note: (*) represents significant at 0.05 level and (**) represents significant at 0.01 level.

SUMMARY AND CONCLUSION

A research has been conducted on evaluation of soil and water quality status entitled as **"Characterization of soil and water quality parameters of Cuddapah block in YSR district of Andhra Pradesh"**. This study was carried out during September-December 2020 where ten different villages were selected from Cuddapah block and collected surface soil samples at a depth of 0-15 cm and water samples were taken and analyzed for various physical and chemical parameters in the laboratory by using standard protocols. The correlation matrix between various quality parameters of soil and water were also studied. The conspicuous findings of the present investigation are summarized as follows:

5.1 Analysis of soil samples in Cuddapah block

- The Bulk density and Particle density of the soil samples were ranged from 1.17 -1.47 Mg/m^3 and 2.08-2.64 Mg/m^3 with 1.32 and 2.37 Mg/m^3 as the mean values.
- The Porosity percentage of the soil samples were ranged from 37.0-50.2% with 44.0 % as the mean value and water holding capacity values in the soil samples were ranged from 33.4-56.4% with 43.4% as a mean value.
- The pH of the soil samples were identified as alkaline to neutral in condition with the values ranged from 6.8 to 8.5 with 7.6 as a mean value. The current findings concluded that 27.5% of the soil samples were in neutral condition whereas 72.5% of the soil samples were in alkaline nature.
- The Electrical Conductivity values of the soil samples were ranged from 0.094 to 1.273 dS/m with 0.527 dS/m as a mean value. The current findings observed that 67.5 % of the soil samples are in permissible range and is suitable for all crop types and 32.5 % of the samples are slightly higher than the permissible limit but suitable for most of the crops.

- The organic carbon content in the soil samples were ranged from 0.24 to 1.18% with 0.63 as the mean value. The current findings concluded that 30 % of the soil samples were recorded as high in range, 37.5% of the samples recorded as low range and 32.5 % of the soil samples were found in medium range.
- The available Nitrogen content in the soil samples were found medium to low range. The range of available nitrogen in the soil samples were varied from 76.3 to 708.2 kg/ha with 298.4 kg/ha as a mean value. The current findings concluded that 57.5% of the soil samples were reported as low range of nitrogen content,32.5% of the soil samples were reported as medium range of nitrogen content and 10% of the soil samples were reported as high range of nitrogen content.
- The available phosphorous content in the soil samples were found medium in range. The range of available phosphorous in the soil samples were varied from 4.18 to 44.9 kg/ha with 19.5 kg/ha as a mean value. The current findings concluded that 37.5 % of the soil samples were reported as low range in phosphorous content , 32.5% of the soil samples were reported as medium range in phosphorous content and 30% of the soil samples were reported as high range in phosphorous content.
- The available potassium content in the soil samples were found medium to high range. The range of available potassium in the soil samples were varied from 78.6 to 864.4 kg/ha with 385.8 kg/ha as a mean value. The current findings concluded that 7.5 % of the soil samples were reported as low range in potassium content, 40% of the soil samples were reported as medium range in potassium content and 52.5% of the soil samples were reported as high range in potassium content.
- The exchangeable calcium content in the soil samples were found as high range. The range of exchangeable calcium in the soil samples were varied from 0.43 to 6.7 Meq/100gm with 2.49 Meq/100gm as a mean value. The current findings concluded that 22.5% of the soil smples were reported as low

range in calcium content whereas 77.5% of the soil samples were reported as high range in calcium content.

- The exchangeable magnesium content in the soil samples were found as low range. The range of exchangeable magnesium content in the soil samples were varied from 0.18 to 2.72 Meq/100 gm with 0.87 as a mean value. The current findings concluded that 62.5% of the soil samples were reported as low range in magnesium content whereas 37.5% of the soil samples were reported as high range in magnesium content.
- The available sulphur content in the soil samples were found in high range. The range of available sulphur in the soil samples were varied from 0.16 to 1.14 mg/kg with 0.45 mg/kg as a mean value. The current findings concluded that the soils of Cuddapah block have low contentration of sulphur content where 100% of the soil samples were reported as low range in sulphur content.
- The available Iron content in the soil of Cuddapah block were found to be sufficient in range. The range of available iron in the soil samples were varied from 1.0 to 12.4 mg/kg with 5.37 mg/kg as a mean value. The current findings concluded that low range of iron content was found in 25% of the soil samples, medium range of the iron content was found in 55% of the soil samples and high range of the soil samples was found in 20% of the soil samples.
- The available Copper content in the soil samples were found to be sufficient in range. The range of available copper in the soil samples were varied from 0.1 to 8.3 mg/kg with 3.07 mg/kg as a mean value. The current findings concluded that 15% of the samples were reported as deficient range , 75% of the soil samples were reported as sufficient in copper content and 10% of the soil samples were reported as excess in copper content .
- The available Manganese content in the soil samples were found to be excess in range. The range of available manganese in the soil samples were varied from 0.6 to 10.0 mg/kg with 2.46 mg/kg as a mean value. The current findings concluded that 12.5% of the soil samples were reported as excess range,

22.5% of the samples were reported as sufficient in zinc whereas 65% of the samples were reported as deficient in available manganese content.

- The available Zinc content in the soil samples were found to be sufficient to excess in range .The range of available Zinc in the soil samples were varied from 0.1 to 4.5 mg/kg with 1.08 mg/kg as a mean value. The current findings concluded that 55% of the samples were reported as deficient condition, 32.5% of the soil samples were reported as sufficient in zinc content whereas 12.5% of the soil samples were reported as excess range in available zinc content.

5.2 Analysis of water samples in Cuddapah block

- The pH of the ground water samples of Cuddapah block are neutral to slightly alkaline in condition and their values ranged from 7.0 to 8.3 with 7.61 as a mean value. The current findings concluded that suitable range of pH was reported in 100% of the samples.
- The EC range in the water samples were varied from 0.279 to 3.642 dSm^{-1} with 1.425 dSm^{-1} as a mean value. The current findings concluded that suitable range of EC was reported in 10% of the samples, moderately suitable range of EC was reported in 82.5% of the samples and not suitable range of EC was reported in 12.5 % of the water samples.
- The chloride concentration range in the water samples were varied from 1.6 to 28.4 Meq/L with 6.97 Meq/L as a mean value. The current findings concluded that suitable range of chloride concentration was reported in 22.5% of the samples, moderately suitable range of chloride was reported in 65% of the samples and not suitable range of chloride concentration was reported in 12.5% of the water samples.
- The bicarbonate concentration in the water samples were varied from 1.6 to 5.2 Meq/L with 3.17 Meq/L as the mean value. The potassium concentration range in the water samples were varied from 0.025 to 0.793 Meq/L with 0.239 Meq/L as the mean value.

- The sodium concentration range in the water samples were varied from 0.56 to 3.87 Meq/L with 1.83 as a mean value. The current findings concluded that suitable range of sodium was reported in 92.5% of the samples , moderately suitable range of sodium concentration was reported in 7.5 % of the water samples. The calcium plus magnesium range in the water samples were varied from 8.4 to 46.2 Meq/L with 23.3 Meq/L as the mean value.
- The irrigation water quality index (IWQI) range in the water samples were varied from 86.7 to 504.6 with 236.7 as the mean value and reported that 37.5% of the water samples are in poor rage for irrigation , 37.5% of the samples were found under very poor range for irrigation, 22.5% of the samples were found to be unsuitable for the irrigation use and 2.5 % of the samples were found in suitable range for its usage in irrigation purpose.
- The range of SAR values in the water samples were varied from 0.17 to 1.44 Meq/L with 0.58 Meq/L as the mean value. It was observed that 100% of the samples are within the permissible limit and belongs to class S1 which indicates no sodium hazard therefore the ground water samples are in suitable range for the usage in irrigation purpose.
- The range of SSP concentration in the water samples were varied from 14.88 to 68.18 with 35.44 as the mean value. The range of residual sodium carbonate concentration in the water samples were varied from - 44 to - 5.2 with -20.16 as a mean value.
- The range of KR and PI concentration in the water samples were varied from 0.02 to 0.30 and 7.55 to 37.8 with 0.09 and 16.84 as their mean values.

CONCLUSION

The results of soil analysis has been interpreted by using the literature which helps the farmers to analyze and to add up the deficient nutrients. According to the soil test results of Cuddapah block , it clearly declared that the soil is alkaline to neutral in condition. 62.5 % of the soil samples have shown medium to high organic carbon content. By considering nutrient index the soils of Cuddapah block are low in nitrogen and sulphur due to lack of application of fertilizers and nutrient removal by crops whereas medium in organic carbon and phosphorous and high in potassium. Micronutrients i.e, Iron and Copper are in sufficient range due to addition of micronutrient fertilizers and parent material and organic carbon whereas Manganese and Zinc were found as deficient condition because of inverse relationshiop with pH which means increase in the pH causes reduction in availability of these nutrients. Due to indiscriminate use of fertilizers and pesticides by the farmers and due to inappropriate cultivation practices soluble salts have been accumulated that results in moderate range of EC concentration in the samples.

The pH of the water samples was found to be neutral to slightly alkaline in nature . The calcium and magnesium concentration of the water samples were high and above the permissible range. 72.5% of the water samples indicated poor to very poor irrigation water quality index and 25% of the water samples were reported as unsuitable for its use in irrigation which is due to high calcium and magnesium concentration, moderate range of soluble salts in water samples and location of big factories and chemical industries near the area. This indicates that the farmers should be informed and educated about sewage contamination , household products containing hazardous substance and better management of disposal of industrial waste. It is concluded that the deficient nutrients have to be restored by adding chemical fertilizers and/or through organic manures in proper amounts to maintain soil health. A farming system needs to be developed which includes both soil enriching and restoring for efficient sustainable crop production. The results strongly recommends that still improvement has to be done to upgrade the quality of irrigation water and better management for maintaining sustainable productivity by improving the management practices.

BIBLIOGRAPHY

Anbazhagan. S., Das. M.K. and Balamurugan. G. (2014). Hydro geo-chemical studies in hard rock aquifer system, Hosur, India. *Indian Journal of Geo-Chemistry*, **22**(2): 519-535.

APHA. (1992). Standard methods for the examination of water and waste waters. *American Public Health and Association,* 18^{th} Edition, Washington.

Aradhana Barooah , Hiranya Kumar Bhattacharya and Karma Bhadur Chetri (2020). Assessment of Soil fertility of some villages of Lahowal block, Dibtrugarh, India. *International Journal of Current Microbiology and Applied Sciences*, **9**(80): 1438-1450.

Aravinthasamy. P., Karunanidhi. D., Subba Rao. N., Subramani. T. and Srinivasamoorthy. K. (2020). Irrigation risk assessment of ground water in a non-perennial river basin of South India: implication from irrigatiom water quality index (IWQI) and geographical information system (GIS) approaches. *Arabian Journal of Geosciences,* **13**: 1-14.

Arivoli Appavu, Sathiamoorthi Thangavelu, Satheeshkumar Muthukannan, Joseph Sahayarayan Jesudoss and Boomi Pandi (2016). Study of Water Quality Parameters of Cauvery river water in Erode region. *Journal of Global Biosciences*, **5**(90): 4556-4567.

Awinash Kumar, Mishra. V. N., Srivastav. L.K., and Rakesh Banwasi (2014). Evaluations of soil fertility status of Available major nutrients (N, P and K) and Micronutrients (Fe, Mn, Cu &Zn) in Vertisol of Kabeerdham district of Chattisgarh, India. *International Journal of Interdisciplinary and Multidisciplinary Studies,* **1**(10): 72-79.

Ayers R.S. and Westcott D.W. (1985). Water quality for agriculture. *Rome FAO 29,* 37-70.

Babiker. S., Mohamed. A. and Tetsuya Hiyama (2007). Assessing the ground water quality using GIS. *Water resource management,* **21**(4): 699-715.

Basvaraja. P.K., Dey. P., Mohamed Saqeebulla. H. and Yogendra. N.D. (2017). Geo-reference based soil fertility status in Hasan district of Karnataka, India for development of nutrient plan. *Indian Journal of Soil Conservation* , **45**: 141-147.

Bharti. V.S., Dotaniya. M.L., Shukla. S.P. and Yadav. V.K. (2017). Managing soil fertility through microbes : prospects, challenges and future strategies. In:Agro Environmental Sustainability (Singh. J.S., Seneviratne. G. Eds.), Springer, Pp. 81-111. DOI 10. 1007/978-3-319-49724-2-5.

BIS (1991). Indian drinking water standards. First revision, edition 2.1.

Black. C.A. (1965). Methods of Soil Analysis . Part 1 and 2. *American Society of Agronomy*, Inc.,Madison, Wisconsin, U.S.A., 1-2: 1572.

Camberdella. C.A. and Karlen. D.L. 1999. Spatial analysis of soil fertility parameters. *Precision Agriculture.* **1**(1): 5-14.

Chandak. N., Shabana. M.B.P., Meena. D. and Kamlesh. S. (2017). Analysis of Soil Samples for its Physico-Chemical Parameters from Kadi city. *Newest International Referred Journals*, **1**: 2349-3372.

Charu Parashar, Neelam Verma, Savitha Dixit and Rajneesh Shrivastava (2008). Multivariate analysis of drinking water quality parameters in Bhopal, India. *Environmental Monitoring and Assessment*, **140**: 119-122.

Chaudhari. P.R., Ahire. D.V., Ahire. V.D., Chakravarty. M. and Maity. S. (2013). Study of Soil bulk density as related to soil texture, Organic matter contents and available total nutrients of Coimbatore soil. *International Journal of Scientific and Research publications*, **3**(2): 1-8.

Debnath. P., Deb. P., Sen. D., Pattannaik. S.K., Sah. D. and Ghosh. S.K. (2012). Physico-chemical properties and its relationship with water holding capacity of cultivated soils along altitudinal gradient in sikkim. *International Journal of Agriculture Environment and Biotechnology*, **5**(1): 99-102.

Devojee. B., Nagababu. G., Manoj kumar. M.,Y., Nandini and Hemakumar. H.V. (2018). Assessment of Mapping of irrigation water quality index of Bapatla mandal, Guntur district, Andhra Pradesh, India. *International Journal of Current Microbiology and Applied Sciences,* **7**(1): 1914-1920.

Dhirendra Mohan Joshi, Alok Kumar and Namita Agrawal (2009). Assessment of the Irrigation Water Quality of river Ganga in Haridwar District, Uttarakhand, India. *Rasayan Journal of chemistry,* **2**(2): 285-292.

Doneen. L.D. (1964). Water quality for agriculture. Department of irrigation, *University of California,* p: 48.

Eaton. F.M. (1950) Significance of Carbonate in irrigation water. *Soil Science*, **69**: 123-133.

FAO (1994). Water quality for Agriculture FAO irrigation drainage paper, No: 29,rev.1. Food and Agriculture Organization of the United Nations, Rome.

Haritash. A.K., Shalini Gaur and Sakshi Garg (2016). Assessment of water quality and suitability analysis of River Ganga in Rishikesh, India. *Appled Water Sciences*, **6**: 383-392.

Indian Council of Medical Research (ICMR) (1975). Manual of Standards of Quality for Drinking Water Supplies. Special Report Series No. 44. New Delhi.

Jackson. M.L. (1973). Soil Chemical Analysis. *Prentice Hall of India Pvt. Ltd.,* New Delhi.

Jain S.A., Jagtap. M.S. and Patel. K.P. (2014). Physico-Chemical Characterization of farmland Soil used in some villages of Lunawada Taluka . Dist: Mahisagar (Gujarat) India. *International Journal of Scientific and Research Publications,* **4**(3): 1-5.

Janardhana Raju. N. (2007). Hydrogeochemical parameters for assessment of groundwater quality in the upper Gunjaneru River basin, Cuddapah district, Andhra Pradesh, South India. *Environmental Geology,* **52**:1067-1074.

Jothivenkatachalam. K., Nithya. A. and Chandra Mohan. S. (2010). Correlatiom analysis of drinking water quality in and around perur block of Coimbatore district, Tamil Nadu, India. *Rasayan Journal of Chemistry,* **3**(4): 649-654.

Kadam. P.M. and Balasaheb. U.K. (2016). Physicochemical Properties and its Relationship with Water Holding Capacity of Soil in Deulgaon Raja region , Maharashtra. *Science and Technology,* **2**(6): 49-52.

Karanth. K. R. (1987). Ground Water Assessment Development and Management (New York: McGraw-Hill), pp.52-89.

Kavitha C. and Sujatha. M.P. (2015). Evaluation of soil fertility status in various agroecosystems of Trissur district, Kerala, India. *International Journal of Agriculture and Crop Sciences*, **8**: 328-338.

Kelly. W.P. (1953). Use of Saline Irrigation Water. *Soil Science* , **95**(6): 385-391.

Khursheed Ahmed Wani, Rajni Yadav, Shivom Singh and Krishan Kant Upadhyay (2014). Comparative study of Physicochemical properties and Fertility of soils in Gwalior, Madhya Pradesh. *World Journal of Agricultural Sciences*, **10**(2): 48-56.

Krishna Kumar Yadav, NehaGupta, Vinit Kumar, Sandeep Arya and Deepak Singh (2012). Physico-chemical analysis of selected groundwater water samples of Agra city, India. *Recent Research in Science and Technology*, **4**(11): 51-54.

Kumarasamy. P., Hans-Uwe Dahms, Hyoung-Joo Jeon. A., Rajendran,R. and Arthur James (2013). Irrigation water quality assessment –an example from the Tamiraparani river, *Southern India.Arabian Journal of Geosciences,* **7**: 5209-5220.

Madhavi. E., Syamkumar. B. and Raja Sekhar. P.S. (2018). Assessment of soil quality under Rice (oryza sativa) Cropping Systems, Yelsmanchili mandal , Visakhapatnam district, Andhra Pradesh, India. *Journal of Pharmaceutical Chemical and Biological Sciences*, **6**(2): 35-41.

Madhu. B.M. and Arun A. David (2017).Soil Fertility Status of Jamuna Paar region of Allahabad District, Uttarpradesh, India. *International Journal of Current Microbiology and Applied Sciences*, **6**(12): 3069-3076.

Magesh. N.S., Krishnakumar. S., Chandrasekar. N. and John Prince Soundranayagan (2012). Groundwater quality assessment using WQI and GIS techniques, Dindigul district, Tamil Nadu, India. *Arab Journal of Geosciences*, **6**: 4179-4189.

Manish Kumar, Kalpana Kumari, Ramanathan. A.L. and Rajinder Saxena (2007). A comparative evaluation of ground water suitability for irrigation and drinking purposes in two intensively cultivated districts of Punjab, India. *Environmental Geology*, **53**: 553-574.

Meireless, Andrade,Chavas,Frischkorn, H. and Crisostomo (2010). A new proposal of the classification of the Irrigation Water. *Revista Ciencia Agronomica*, **41**(3): 349-357.

Muhr. G.R., Datta. N. P., Subramany. N.S., Dever. F., Lecy. V.K. and Donahue. R.R. (1963). Soil testing in India. *USDA Publication*, pp: 120.

Nag. S.K. and Das. S. (2014). Quality Assessment of Groundwater with Special Emphasis on Irrigation and Domestic Suitability in Suri I & II Blocks, Birbhum District, West Bengal, India. *American Journal of Water Resources*, **2**(4): 81-98.

Nagaraja. N., Desai. N.B., and Jayanna. H.S. (2014). A comparative study on the physico-chemical parameters of the soils of Chitradurga district , Karanataka. *Indian Journal of Scientific Research*, **5**(2): 23-28.

Namita Saxena and Alka Sharma (2017). Evaluation of water quality index for Drinking purpose in and around Tekanpur area, Madhya Pradesh, India. *International Journal of Applied Environmental Sciences*, **12**(2): 359-370.

Narsaiah. E., Ramprakash. T., Chandinipatnaik. M., Vishnuvardhan Reddy. D. and Bhupal Raj. G. (2018). Soil physical, physico-chemical properties of Mulugu division soils of Warangal district. *International Journal of Current Microbiology and Applied Sciences*, **7**(6): 2735-2748.

Nath. T.N. (2014). Soil texture and total organic matter content and its influences on soil water holding capacity of some selected Tea growing soils in Sivasagar district of Assam, India. *International Journal of Chemical Sciences*, **12**(4):1419-1429.

Omran E-SE, Ghallab. A., Selmy. S., Gad A-A (2014). Evaluation and mapping water wells suitability for irrigation using GIS in Darb EI-Arbaein, South Western Desert, Egypt. *International Journal of Water Resources and Arid Environments*, **3**: 63-76.

Ondersteijn. C.J.M., Giesen. G.W.J. and Huirine. R.B.P. 2003. Identification of farmer's characteristics and farm strategies explaining changes in environmental and economic performance of dairy farms. *Agricultural Systems*, **78**: 31-35.

Parker. F.W., Nelson. W.L., Winters. E. and Miles. A.E. (1951). The board interpretation and application of soil test summaries. *Agronomy Journal*, 43(3): 103-112.

Piper. C.S. (1966). Soil and Plant analysis. *Hans Publisher*, Bombay.

Pravin. R., Chaudhari, Dodha V. Ahire, Vidya. D. Ahire, Manab Chakravarty and Saroj Maity (2013). Soil Bulk Density as related to soil texture , organic matter content and available total nutrients of Coimbatore soil. *International Journal of Scientific and Research Publications*, **3**(20): 1-8.

Pujar. K.G., Hiremath. S.C., Pujar. A.S., Pujeri. U.S. and Yadawe. M.S. (2012). Analysis of Physico-chemical and Heavymetal concentration in soil of Bijapur taluka, Karnataka. *Scientific Reviews and Chemical Communications*, **2**(1): 76-79.

Pulakeshi. H.B.P., Patil. P.L., Dasog. G.S., Radder B.M., Bideri. B.I. and Mansur. C.P. (2012). Mapping of nutrients status by geographic information (GIS) in Mantagani village under northern transition zone of Karanataka. *Journal of Agriculture Science*, **25**(3): 332-335.

Qureshimatva. U.M., Maurya. R.R., Gamit. S.B., Patel. R.D and Solanki. H.A. (2015). Determination of physico-chemical parameters and Water quality index (WQI) of Chandlodia lake, Ahmedabad, Gujarat, India. *Environmental and Analytical Toxicology*, **5**(4): 1-6.

Rajeshwar Malavath and Mani. S. (2018). Differences in distribution of Physico-chemical properties and available nutrients status in some red, red laterite and black soils in semi arid region of Tamil Nadu. *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 451-459.

Ram Lokhande. S., Pravin Singare U., and Deepali Pimple. S. (2011). Study of Physico-Chemical parameters of waste water effluents from Tajola Industrial area of Mumbai,India. *International Journal of Ecosystem*, **1**(1): 1-9.

Ramakrishnaiah. C.R., Sadashivaiah. C. and Ranganna. G. (2009) Assessment of Water Quality Index for the Ground water in Tumkur Taluk, Karnataka State, India. *E-Journal of Chemistry*, **6**(2): 523-530.

Ramamoorthy. B., Bajaj. J.C. (1969). Nitrogen, Phosphorous, and Potash status of Indian soils. *Fertilizer News*, **14**: 25-28.

Ramamurthy. V., Radhika. K., Kavitha Amirthanayagi. A. and Raveendran. S. (2012). Physico-chemical analysis of soil and water of Vedaranyam mangrove forest, Tamil Nadu, India. *International Journal of Advanced Life Sciences*, **3**: 65-71.

Ramprasad Naik, Desavathu, Appala Raju Nadipena, Jagadeeswara Rao Peddada. (2018). Assessment of soil fertility status in Paderu Mandal, Visakhapatnam district of Andhra Pradesh through Geospatial techniques. *The Egyptian Journal of Remote Sensing and Space Sciences*, **21**: 73-81.

Ravikumar. P. and Somashekar. R.K. (2014). Spatial distribution of macronutrients in soils of Markandeya river basin, Belgaum(d), Karnataka (s), India. *International Academy of Ecology and Environmental Sciences*, **4**(2): 81-94.

Richards. L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils. U.S. *Department of Agriculture Handbook*, Washington D.C., USA. **60**:160.

Rima Chatterjee, Gourab Tarafder (2010). Ground water quality assessment of Dhanbad district, Jharkhand, India. *Bulletin of Engineering Geology and the Environment*, **69**: 137-141.

Sarath Prasanth. S.V., Magesh. N.S., Jitheshal. K.V., Chandrasekar. N. and Gangadhar. N. (2012). Evaluation of groundwater quality and its suitability for drinking and agricultural use in the coastal stretch of Alappuzha district, Kerala, India. *Applied Water Sciences*, **2**: 165-175.

Saravanakumar. K. and Ranjith Kumar. R. (2011). Analysis of water quality parameters of groundwater near Ambattur industrial area, Tamil Nadu, India. *Indian Journal of Science and Technology*, **4**(5): 660-662.

Schollenberger. C.J. and Simon. R.H. (1945). Determination of Exchange Capacity and Exchangeable Bases in Soil-Ammonium Acetate Method. *Soil Science*, **59**: 13-24.

Selvakumar. S., Ramkumar. K., Chandrasekar. N., Magesh. N.S. and Kaliraj. S. (2014). Groundwater quality and its suitability for drinking and irrigational use in the southern Tiruchirapalli district, Tamil Nadu, India. *Applied Water Sciences*, **7**: 411-420.

Sharma. P.K., Anilsood, Setla. R.K., Tur. N.S., Deepak Mehra and Harpinder Singh (2008). Mapping of Macronutrients in soils of Amritsar dsistrict (Punjab)- A GIS Approach. *Journal of the Indian Society of Soil Sciences*, **56**(1): 34-41.

Shivanna. A.M. and Nagendrappa. G. (2014). Chemical Analysis of Soil Samples to Evaluate the Soil Fertility Status of Selected Command Areas of Three Tanks in Tiptur Taluk of Karnataka, India. (2014). *IOSR Journal of Applied Chemistry*, **7**(11): 01-05.

Singh. S.P., Singh. S., Kumar. A. and Kumar. R. (2018). Soil fertility Evaluation for Macronutrients Using Parkers Nutrient Index Approach in Some Soils of Varanasi District of Eastern Uttar Pradesh, India. *International Journal of Pure Applied Biosciences*, **6**(5): 542-548.

Singh. Y.V., Shashi Kant, Singh. S.K., Sharma P.K., Jat., Kumar. M., Shahi. S.K., Jatav. H.S. and Yadav. R.N. (2017). Assessment of Physico-Chemical Characteristics of the Soil of Lahar Block in Bhind district of Madhya Pradesh (India). *International Journal of Current Microbiology and Applied Sciences*, **6**(2): 511-519.

Solanki. H.A. and Chavda. N.H. (2012). Physico-chemical analysis with reference to seasonal changes in soils of Victoria Park Reserve Forest, Bhavnagar (Gujarat). *Life sciences Leaflets*, **8**: 62-68.

Srinivasan. R., Singh S.K., Nayak D.C., and Dharumarajan (2017). Assessment of soil properties and nutrient status in three Horticultural land use system of Coastal Odisha, India. *International Journal of Bio-resource and Stress Management*, **8**(1): 033-040.

Srivastava. P.P., Pandiaraj. T., Susmita Das, Sinha. S.K. and Sinha. A.K. (2017). Assessment of Micronutrient Status in relation to soil characteristics under Tasar growing states of Bihar and Jharkhand, India. *International Journal of Current Research* , **9**(4): 48710-48713.

Subbarao. N. (2005). Seasonal variation of groundwater quality in a part of Guntur district, Andhra Pradesh, India. *Environmental Geology*, **49**: 413-429.

Subbarao. N. (2017). Hydrogeology: problems with solutions. *Prentice Hall of India*, New Delhi.

Sudhakar Gummadi, Swarnalatha. G., Brahmaji Rao. P., Venkataratnamma. V., Vijaya Kumar. G. (2015). Study of Irrigation Water Quality with reference to Coastal Andhra Pradesh, India. *International Journal of modern Engineering research,* **5**(4): 55-60.

Sudheer Kumar Annepu, Mahantesh Shirur and Sharma. V.P. (2017). Assessment of Soil Fertility Status of Mid Himalayan Region, Himachal Pradesh. *Indian Journal of Ecology*, **44**(2): 226-231.

Tanveera. A., Tasawoor. A., Kanth, Parvaiz. A., Tali and Mehrajuddin Naikoo (2016). Relation of soil bulk density with texture , total organic matter content and Porosity in the soils of Kandi area of Kashmir valley, India. *International Research Journal of Earth Sciences*, **4**(1):1-6.

Tisdale. S.L., Nelson. W.L. and Beaton. J. D. (1993). Soil fertility and fertilizers, 5 ed Macmillan publishing Co. Inc. New York and Colloir Macmillan Publishers, London.

Todd. D.K. (1980). Groundwater Hydrology, Second Edition, Wiley, New York.

USDA (1954). U.S. Salinity Laboratory Staff, Diagnosis and Improvement of Saline and Alkali Soils. Handbook 60. Washington, D.C.

Usharani. K., Umarani K., Ayyasamy P.M., Shanthi. K., Lakshmanaperumalsamy. P. (2010). Physico-chemical and Bacteriological Characteristics of Noyyal river and groundwater quality of Perur, India. *Journal of Applied Sciences and Environmental Management*, **14**(2): 29-35.

Vasanthavigar. M., Srinivasamoorthy. K., Vijayaragavan. K., Rajiv. R., Ganthi, Chidambaram. S., Anandhan. P., Manivannan. R. and Vasudevan. S. (2010). Application of water quality index of ground water quality assessment: Thirumanimuttar sub-basin, Tamil Nadu, India. *Environmental Monitoring and Assessment*, **171**: 595-609.

Verma V.K., Patel L.B., Toor. G.S. and Sharma. P.K. (2005). Spatial Distribution of Macronutrients in soils of Arid tract of Punjab, India. *International Journal of Agriculture and Biology*, **7**(2): 295-297.

Vijayakumar. R., Arokiaraj. A. and Martin Deva Prasath. P. (2011). Macronutrient and Micronutrients status in relation to Soil characteristics in South-East coast plain riverine soils of India. *Oriental Journal of Chemistry*, **27**(2): 567-571.

Viji. R. and Rajesh. P.P. (2012). Assessment of water holding capacity of major soil series of Lalgudi, Trichy, India. *Journal of Environmental Research and Development*, **7**(1): 393-398.

Vikas D. Umare (2018). Assessment of Micronutrients and Macronutrients in Soils of Chandrapur Area, Maharashtra, India. *International Journal of research in Advent Technology*, **6**(7): 1744-1747.

Vineet kumar, Ajay Srivastava, Veer Singh, Sarvesh Kumar and Maneesh Bhatt (2018). Availability of macro& micronutrients and their correlation with some physico-chemical properties in soils of Udham Singh nagar district of Uttarakhand. *International Journal of Chemical Studies*, **6**(3): 1445-1449.

Wagh. G.S. and Sayyed. M.R.G. (2013). Assessment of Macro and Micronutrients in Soils from Panvel area, Maharashtra, India. *Universal Journal of Environmental Research and Technology*, **3**(1): 72-78.

Walkley. A. and Black. T.A. (1934). An examination of the Degt. Jarett method for determination of soil organic matter and a proposed modification of chromic acid titration. *Soil Science*, **37**: 29-38.

Wankhande. R.R. (2015). Physico-chemical analysis of soil from some farms of Digras region of Yavatmal district in Maharashtra, India. *Scholedge International Journal of Multidisciplinary and Allied Studies*, **2**(10): 1-4.

Wodaje Addis and Alemayehu Abebaw (2014). Analysis of selected physicochemical parameters of soils used for cultivation of Garlic (Allium sativum L.). *Science,Technology and Arts Research Journal*, **3**(4): 29-35.

World Health Organization (WHO) (2011). Guidelines for Drinking Water Quality, WHO Press, Geneva, Switzerland, 4th edition.

Yogendra. K. and Puttaiah. E.T. (2008). Determination of Water quality index and suitability of an urban waterbody in Shimoga town, Karnataka. The 12th World Lake Conference: 342-346.

Yurembam. G.S , Harish Chandra and Vinod Kumar (2015). Status of Available Macro and Micronutrients in the soils of Someshwar watershed in Almora district of Uttarakhand. An *International Quarterly Journal of Environmental Sciences*, **9**(3&4): 725-73.

APPENDICES

Appendix 1: Description of Soil sampling sites

Village name	Sample No.	Farmers name	Latitude	Longitude	Altitude
Site 1: Mamillapalli	S_1	Narasimhulu	14.437636	78.831338	140 m
	S_2	Ghouse	14.437714	78.831375	141 m
	S_3	Ravi raju	14.436143	78.831062	149 m
	S_4	Subbaiah	14.437085	78.822583	144 m
Site 2: Modimedapalli	S_5	Venkataiah	14.510889	78.839831	120 m
	S_6	Surendra	14.524562	78.845052	121 m
	S_7	Vishnu	14.510842	78.839890	115 m
	S_8	Saraswathi	14.532210	78.846469	118 m
Site 3: Puttlampalli	S_9	Pullaiah	14.449484	78.866318	127 m
	S_{10}	Rajasekhar	14.449492	78.866333	130 m
	S_{11}	Lakshmana	14.449316	78.866689	129 m
	S_{12}	Suresh	14.452641	78.868636	147 m
Site 4: Nanapalli	S_{13}	Sreenivasulu	14.521030	78.843992	111 m
	S_{14}	Subbaraju	14.527819	78.845345	117 m
	S_{15}	Ranga reddy	14.526802	78.845401	116 m
	S_{16}	Simhachalam	14.527835	78.845413	116 m
Site 5: Jamalpalli	S_{17}	Badraiah	14.433764	78.819778	142 m
	S_{18}	Rajesh	14.434628	78.820295	120 m
	S_{19}	Mahendra	14.433772	78.819799	132 m
	S_{20}	Chinnappa	14.433934	78.829772	130 m

Village name	Sample No.	Farmers name	Latitude	Longitude	Altitude
Site 6: Chalamareddypalli	S_{21}	Chalapathy	14.474669	78.869234	147 m
	S_{22}	Balayya	14.476963	78.861354	109 m
	S_{23}	Narasimha	14.477630	78.858391	120 m
	S_{24}	Madana	14.474731	78..869225	147 m
Site 7: Ukkaypalli	S_{25}	Nagaraju	14.490349	78.851043	123 m
	S_{26}	Mallikarjuna	14.490365	78851052	124 m
	S_{27}	Ramaraju	14.496010	78.846610	131 m
	S_{28}	Venkatesh Raju	14.507630	78.839866	117 m
Site 8: Apprajupalli	S_{29}	Sreedar Reddy	14.431919	78.801155	147 m
	S_{30}	Ramanaiah	14.432102	78.801186	149 m
	S_{31}	Sunil Raju	14.431229	78.801306	148 m
	S_{32}	Dheeraj reddy	14.431180	78.801483	148 m
Site 9: Peddamusalreddypalli	S_{33}	Naga mallaiah	14.427296	78.827716	141 m
	S_{34}	Rajalakshmi	14.427372	78.827684	141 m
	S_{35}	Masthan	14.432306	78.825480	136 m
	S_{36}	Sreeramulu	14.432296	78.825534	136 m
Site 10: Subbanavaripalli	S_{37}	Gajendra	14.444058	78.836776	136 m
	S_{38}	Reddaiah	14.444046	78.836807	133 m
	S_{39}	Raghavaiah	14.448947	78.842012	134 m
	S_{40}	Naresh Raju	14.449432	78.840763	133 m

Appendix 2: Status of Bulk density, Particle density, Porosity and WHC in soil

Sample No.	Bulk density (g/cm^3)	Particle density (g/cm^3)	Porosity (%)	Water holding capacity (%)
S_1	1.17	2.10	44.2	54.5
S_2	1.30	2.36	44.9	42.0
S_3	1.34	2.56	47.6	41.2
S_4	1.37	2.26	39.3	40.6
S_5	1.33	2.52	47.2	42.1
S_6	1.33	2.56	48.0	34.9
S_7	1.40	2.63	46.7	50.5
S_8	1.39	2.26	38.4	39.8
S_9	1.32	2.22	40.5	46.7
S_{10}	1.47	2.37	37.9	46.2
S_{11}	1.38	2.28	39.4	42.5
S_{12}	1.35	2.57	47.4	36.1
S_{13}	1.23	2.43	49.3	41.6
S_{14}	1.43	2.42	40.9	33.4
S_{15}	1.27	2.36	46.1	55.7
S_{16}	1.35	2.36	42.7	42.8
S_{17}	1.28	2.44	47.5	34.1
S_{18}	1.36	2.35	42.1	45.2
S_{19}	1.27	2.46	48.3	41.7
S_{20}	1.42	2.62	45.8	53.9
S_{21}	1.19	2.39	50.2	38.9
S_{22}	1.26	2.08	39.4	35.8
S_{23}	1.39	2.46	43.4	46.5
S_{24}	1.36	2.16	37.0	50.8
S_{25}	1.41	2.34	39.7	47.6
S_{26}	1.37	2.35	41.7	42.7
S_{27}	1.19	2.37	49.7	41.8
S_{28}	1.24	2.26	45.1	52.0
S_{29}	1.33	2.64	49.6	41.6
S_{30}	1.34	2.42	44.6	36.8
S_{31}	1.23	2.43	49.3	49.6
S_{32}	1.38	2.33	40.7	37.7
S_{33}	1.30	2.37	45.1	56.4
S_{34}	1.39	2.29	39.3	35.2
S_{35}	1.44	2.49	42.1	40.3
S_{36}	1.37	2.22	38.2	48.5
S_{37}	1.32	2.16	38.8	42.2
S_{38}	1.20	2.41	50.2	38.6
S_{39}	1.29	2.36	45.3	42.0
S_{40}	1.32	2.51	47.8	45.4
MEAN	**1.32**	**2.37**	**44.08**	**43.4**
RANGE	**1.17-1.47**	**2.08-2.64**	**37.0-50.2**	**33.4-56.4**
SD±	**0.073**	**0.138**	**4.05**	**6.11**
CV (%)	**5.55**	**5.82**	**9.20**	**14.09**

Appendix 3: Status of pH, EC and Organic carbon in soil

Sample No.	pH	Electrical Conductivity (dSm^{-1})	Organic carbon (%)
S_1	7.6	0.359	0.92
S_2	7.7	0.286	0.43
S_3	8.2	0.148	0.34
S_4	6.8	0.094	0.62
S_5	8.3	0.118	0.52
S_6	7.8	0.273	0.24
S_7	6.8	0.395	1.12
S_8	6.9	0.220	0.33
S_9	7.9	0.367	0.26
S_{10}	8.3	0.147	0.49
S_{11}	8.5	0.653	0.33
S_{12}	7.6	0.168	0.45
S_{13}	8.0	0.643	0.79
S_{14}	7.2	1.110	0.58
S_{15}	7.3	0.876	0.83
S_{16}	8.1	0.802	0.70
S_{17}	8.5	0.702	0.68
S_{18}	8.2	0.533	0.24
S_{19}	7.6	0.806	0.74
S_{20}	7.1	0.518	0.35
S_{21}	6.8	0.384	0.86
S_{22}	7.8	0.998	0.82
S_{23}	8.3	0.643	0.38
S_{24}	7.0	0.830	0.71
S_{25}	7.7	0.106	0.66
S_{26}	7.2	0.336	0.46
S_{27}	7.2	0.327	0.76
S_{28}	8.1	0.395	0.6
S_{29}	7.1	0.791	0.72
S_{30}	8.2	0.934	0.43
S_{31}	7.7	0.532	0.36
S_{32}	8.0	0.288	0.48
S_{33}	7.8	0.992	0.65
S_{34}	7.6	0.243	0.84
S_{35}	7.8	0.739	1.18
S_{36}	7.9	1.226	1.12
S_{37}	7.0	1.273	0.87
S_{38}	8.0	0.287	0.95
S_{39}	8.3	0.391	0.72
S_{40}	8.0	0.178	0.74
MEAN	**7.6**	**0.527**	**0.63**
RANGE	**6.8-8.5**	**0.094-1.273**	**0.24-1.18**
SD±	**0.51**	**0.32**	**0.24**
C.V(%)	**6.69**	**62.4**	**39.3**

Appendix 4: Status of available primary macronutrients in soil

Sample No.	Nitrogen (kgha^{-1})	Phosphorous (kgha^{-1})	Potassium (kgha^{-1})
S_1	394.4	33.9	302.4
S_2	965	16.8	245.4
S_3	84.9	8.84	190.4
S_4	105.7	42.4	78.6
S_5	110.6	8.84	336.0
S_6	168.5	23.2	268.0
S_7	467.4	44.9	448.0
S_8	98.6	34.5	346.4
S_9	129.2	26.4	538.2
S_{10}	166.1	8.17	100.8
S_{11}	234.6	4.24	313.6
S_{12}	248.7	18.6	235.2
S_{13}	276.1	8.07	313.6
S_{14}	235.4	36.8	616.0
S_{15}	526.5	28.1	425.6
S_{16}	342.8	17.5	280.0
S_{17}	467.2	7.66	638.8
S_{18}	76.3	5.36	89.40
S_{19}	138.9	16.5	294.2
S_{20}	165.0	35.4	280.0
S_{21}	586.7	43.2	339.6
S_{22}	696.8	8.09	708.0
S_{23}	188.0	4.24	628.4
S_{24}	455.6	31.6	361.0
S_{25}	226.1	13.1	418.2
S_{26}	175.0	23.3	436.0
S_{27}	302.6	21.2	247.0
S_{28}	274.0	6.87	236.0
S_{29}	695.3	30.2	864.4
S_{30}	167.2	4.18	728.2
S_{31}	118.0	13.6	559.0
S_{32}	134.9	29.3	178.2
S_{33}	312.6	13.8	259.0
S_{34}	454.0	18.0	232.0
S_{35}	7082	12.4	547.2
S_{36}	546.4	16.5	406.8
S_{37}	317.7	39.0	287.0
S_{38}	223.8	8.17	703.2
S_{39}	389.0	4.80	384.4
S_{40}	432.6	12.1	568.0
MEAN	**298.4**	**19.5**	**385.8**
RANGE	**76.3-708.2**	**4.18-44.9**	**78.6-864.4**
S.D$\pm$	**182.9**	**12.4**	**189.1**
C.V(%)	**61.2**	**63.6**	**49.0**

Appendix 5: Status of available secondary macronutrients in soil

Sample No.	Calcium(Meq/100gm)	Magnesium(Meq/100gm)	Sulphur(mgkg^{-1})
S_1	2.92	1.00	0.65
S_2	1.16	0.84	0.38
S_3	2.60	1.32	0.41
S_4	2.74	0.38	0.21
S_5	3.78	0.50	0.37
S_6	3.18	1.08	0.29
S_7	1.50	0.50	1.05
S_8	2.54	1.68	0.19
S_9	3.56	0.26	0.6
S_{10}	2.04	0.6	0.29
S_{11}	4.22	1.68	0.49
S_{12}	2.42	0.52	0.36
S_{13}	2.60	0.36	0.29
S_{14}	1.92	0.74	0.26
S_{15}	1.64	1.26	0.44
S_{16}	1.46	0.58	0.39
S_{17}	2.70	0.24	0.29
S_{18}	3.04	1.84	0.53
S_{19}	3.10	1.02	0.35
S_{20}	2.46	0.18	0.48
S_{21}	1.94	0.72	0.16
S_{22}	0.43	0.70	0.38
S_{23}	3.46	1.32	0.64
S_{24}	1.90	2.16	1.14
S_{25}	0.78	0.34	0.62
S_{26}	2.30	0.46	0.21
S_{27}	4.28	1.24	0.39
S_{28}	0.86	0.70	0.25
S_{29}	3.16	2.72	0.25
S_{30}	4.00	1.90	0.62
S_{31}	2.90	0.28	0.27
S_{32}	6.70	0.56	0.70
S_{33}	3.96	0.44	0.56
S_{34}	0.94	0.28	0.41
S_{35}	0.88	1.26	1.06
S_{36}	2.72	0.94	0.98
S_{37}	198	0.60	0.37
S_{38}	3.56	0.34	0.23
S_{39}	0.60	1.36	0.34
S_{40}	1.08	0.20	0.39
MEAN	**2.49**	**0.87**	**0.45**
RANGE	**0.43-6.70**	**0.18-2.72**	**0.16-1.14**
S.D$\pm$	**1.25**	**0.60**	**0.24**
C.V(%)	**50.3**	**68.76**	**53.9**

Appendix 6: Status of available micronutrients in soil

Sample No.	Iron($mgkg^{-1}$)	Copper($mgkg^{-1}$)	Manganese($mgkg^{-1}$)	Zinc($mgkg^{-1}$)
S_1	3.0	2.2	2.6	0.3
S_2	3.2	3.4	1.7	1.2
S_3	4.3	1.1	0.9	0.5
S_4	12	6.8	2.4	4.1
S_5	1.8	1.5	1.1	0.3
S_6	11.4	1.7	3.3	1.2
S_7	12.0	7.0	1.6	0.4
S_8	3.2	5.0	3.6	3.2
S_9	12.4	1.9	2.7	1.4
S_{10}	2.2	6.2	1.8	0.5
S_{11}	2.2	3.9	1.2	0.1
S_{12}	4.0	4.2	2.5	0.5
S_{13}	7.0	2.4	1.0	0.3
S_{14}	4.2	4.6	5.6	4.2
S_{15}	10.1	3.3	1.1	1.0
S_{16}	1.6	0.7	1.6	0.4
S_{17}	2.0	0.4	1.7	0.2
S_{18}	5.4	5	3.6	0.2
S_{19}	2.3	4.1	1.6	0.5
S_{20}	9.3	4.3	10	3.0
S_{21}	6.2	8.3	6.4	4.5
S_{22}	3.4	7.4	1.9	0.4
S_{23}	12	0.2	1.0	0.6
S_{24}	9.2	4.5	5.5	1.3
S_{25}	1.0	2.4	1.0	0.2
S_{26}	12	3.5	1.8	0.3
S_{27}	3.4	3.2	1.7	1.4
S_{28}	6.6	2.0	1.9	1.2
S_{29}	7	3.1	3.6	1.3
S_{30}	3.3	0.2	0.8	0.5
S_{31}	1.9	4.0	1.6	1.2
S_{32}	7.2	0.1	1.7	0.3
S_{33}	3.9	0.8	0.6	1.4
S_{34}	4	4.8	2.7	0.4
S_{35}	2.8	3.9	7.2	1.3
S_{36}	1.2	0.2	1.6	0.2
S_{37}	6.0	0.2	2.0	1.4
S_{38}	4.2	3.2	1.6	1.1
S_{39}	3.8	0.1	1.0	0.4
S_{40}	2.3	1.0	1.2	0.5
MEAN	**5.37**	**3.07**	**2.46**	**1.08**
RANGE	**1.0-12.4**	**0.1-8.3**	**0.6-10.0**	**0.1-4.5**
S.D±	**3.57**	**2.21**	**1.96**	**1.14**
C.V(%)	**66.4**	**72.2**	**80.03**	**105.4**

Appendix 7: Description of water sampling sites.

Village name	Sample No.	Farmers name	Latitude	Longitude	Altitude
Site 1: Mamillapalli	W_1	Narasimhulu	14.437636	78.831338	140 m
	W_2	Ghouse	14.437714	78.831375	141 m
	W_3	Ravi raju	14.436143	78.831062	149 m
	W_4	Subbaiah	14.437085	78.822583	144 m
Site 2: Modimedapalli	W_5	Venkataiah	14.510889	78.839831	120 m
	W_6	Surendra	14.524562	78.845052	121 m
	W_7	Vishnu	14.510842	78.839890	115 m
	W_8	Saraswathi	14.532210	78.846469	118 m
Site 3: Puttlampalli	W_9	Pullaiah	14.449484	78.866318	127 m
	W_{10}	Rajasekhar	14.449492	78.866333	130 m
	W_{11}	Lakshmana	14.449316	78.866689	129 m
	W_{12}	Suresh	14.452641	78.868636	147 m
Site 4: Nanapalli	W_{13}	Sreenivasulu	14.521030	78.843992	111 m
	W_{14}	Subbaraju	14.527819	78.845345	117 m
	W_{15}	Ranga reddy	14.526802	78.845401	116 m
	W_{16}	Simhachalam	14.527835	78.845413	116 m
Site 5: Jamalpalli	W_{17}	Badraiah	14.433764	78.819778	142 m
	W_{18}	Rajesh	14.434628	78.820295	120 m
	W_{19}	Mahendra	14.433772	78.819799	132 m
	W_{20}	Chinnappa	14.433934	78.829772	130 m

Village name	Sample No.	Farmers name	Latitude	Longitude	Altitude
Site 6: Chalamareddypalli	W_{21}	Chalapathy	14.474669	78.869234	147 m
	W_{22}	Balayya	14.476963	78.861354	109 m
	W_{23}	Narasimha	14.477630	78.858391	120 m
	W_{24}	Madana	14.474731	78..869225	147 m
Site 7: Ukkaypalli	W_{25}	Nagaraju	14.490349	78.851043	123 m
	W_{26}	Mallikarjuna	14.490365	78851052	124 m
	W_{27}	Ramaraju	14.496010	78.846610	131 m
	W_{28}	Venkatesh Raju	14.507630	78.839866	117 m
Site 8: Apprajupalli	W_{29}	Sreedar Reddy	14.431919	78.801155	147 m
	W_{30}	Ramanaiah	14.432102	78.801186	149 m
	W_{31}	Sunil Raju	14.431229	78.801306	148 m
	W_{32}	Dheeraj reddy	14.431180	78.801483	148 m
Site 9: Peddamusalreddypalli	W_{33}	Naga mallaiah	14.427296	78.827716	141 m
	W_{34}	Rajalakshmi	14.427372	78.827684	141 m
	W_{35}	Masthan	14.432306	78.825480	136 m
	W_{36}	Sreeramulu	14.432296	78.825534	136 m
Site 10: Subbanavaripalli	W_{37}	Gajendra	14.444058	78.836776	136 m
	W_{38}	Reddaiah	14.444046	78.836807	133 m
	W_{39}	Raghavaiah	14.448947	78.842012	134 m
	W_{40}	Naresh Raju	14.449432	78.840763	133 m

Appendix 8: Status of available pH and EC in water

Sample No.	Water pH	Water EC (dSm^{-1})
W_1	7.5	1.642
W_2	7.2	0.279
W_3	7.4	0.466
W_4	7.7	0.398
W_5	7.6	0.785
W_6	7.3	1.416
W_7	7.9	0.779
W_8	8.0	0.949
W_9	7.8	0.876
W_{10}	7.7	1.271
W_{11}	7.7	1.128
W_{12}	7.8	1.277
W_{13}	7.5	1.666
W_{14}	7.4	2.587
W_{15}	7.7	1.143
W_{16}	7.6	0.490
W_{17}	7.6	0.844
W_{18}	8.3	0.961
W_{19}	7.8	1.187
W_{20}	7.1	0.786
W_{21}	7.5	1.810
W_{22}	7.5	1.972
W_{23}	7.2	1.629
W_{24}	7.7	2.625
W_{25}	7.3	1.230
W_{26}	7.2	0.989
W_{27}	7.0	3.178
W_{28}	7.2	0.837
W_{29}	8.2	1.970
W_{30}	8.2	0.975
W_{31}	7.6	1.586
W_{32}	7.8	0.618
W_{33}	7.5	3.642
W_{34}	8.3	2.164
W_{35}	8.2	3.322
W_{36}	8.2	0.996
W_{37}	7.1	1.564
W_{38}	7.2	1.134
W_{39}	7.8	2.767
W_{40}	7.4	1.092
MEAN	**7.6**	**1.425**
RANGE	**7.0 – 8.3**	**0.279-3.642**
S.D±	**0.35**	**0.81**
C.V(%)	**4.66**	**57.5**

Appendix 9: Status of available anions in water

Sample No.	Carbonate(Meq/lit)	Bicarbonate(Meq/lit)	Chloride(Meq/lit)
W_1	0	4.2	6.8
W_2	0	3.8	1.6
W_3	0	3.6	2.0
W_4	0	2.8	2.4
W_5	0	2.8	3.2
W_6	0	2.0	6.0
W_7	0	3.8	3.2
W_8	0	3.2	9.6
W_9	0	4.0	6.4
W_{10}	0	3.4	4.0
W_{11}	0	4.4	4.0
W_{12}	0	4.2	2.8
W_{13}	0	2.0	8.0
W_{14}	0	2.0	13.6
W_{15}	0	2.4	5.2
W_{16}	0	4.6	3.2
W_{17}	0	4.0	4.4
W_{18}	0	3.8	5.2
W_{19}	0	2.2	4.8
W_{20}	0	2.8	4.4
W_{21}	0	2.6	9.2
W_{22}	0	3.4	3.6
W_{23}	0	3.2	28.4
W_{24}	0	3.2	21.6
W_{25}	0	4.0	4.0
W_{26}	0	4.8	4.8
W_{27}	0	4.4	21.6
W_{28}	0	1.8	5.6
W_{29}	0	1.8	7.6
W_{30}	0	2.4	4.4
W_{31}	0	2.2	6.8
W_{32}	0	2.0	5.8
W_{33}	0	3.0	5.0
W_{34}	0	4.0	5.6
W_{35}	0	5.2	9.8
W_{36}	0	3.8	6.4
W_{37}	0	3.8	3.8
W_{38}	0	1.6	7.8
W_{39}	0	1.8	10.2
W_{40}	0	2.0	6.2
MEAN	**0**	**3.17**	**6.97**
RANGE	**0**	**1.6-5.2**	**1.6-28.4**
S.D±	**0**	**0.98**	**5.53**
C.V (%)	**0**	**30.9**	**79.2**

Appendix 10: Status of available cations in water

Sample No.	Calcium + Magnesium (Meq/lit)	Calcium (Meq/lit)	Sodium (Meq/lit)	Potassium (Meq/lit)	Magnesium (Meq/lit)
W_1	25.6	17.8	1.30	0.128	7.8
W_2	9.0	6.2	1.56	0.076	2.8
W_3	16.4	9.0	1.00	0.076	7.4
W4	11.0	5.4	3.39	0.128	5.6
W_5	26.8	6.8	0.73	0.102	20.0
W_6	18.6	15.0	2.08	0.102	3.6
W_7	24.0	5.8	0.73	0.102	18.2
W_8	17.4	8.2	1.74	0.793	9.2
W_9	20.7	6.4	2.13	0.025	14.3
W_{10}	33.0	20.4	2.08	0.102	12.6
W_{11}	21.2	14.2	0.56	0.307	7.0
W_{12}	28.8	8.2	0.91	0.025	20.6
W_{13}	29.6	5.6	1.52	0.128	24.0
W_{14}	17.4	9.8	3.87	0.102	7.6
W_{15}	13.0	7.4	1.13	0.102	5.6
W_{16}	13.4	6.0	2.31	0.435	7.4
W_{17}	13.0	6.8	1.26	0.153	6.2
W_{18}	34.2	16.4	0.95	0.102	17.8
W_{19}	20.8	11.4	1.43	0.076	9.4
W_{20}	8.4	6.6	2.43	0.102	1.8
W_{21}	18.0	9.8	2.74	0.128	8.2
W_{22}	35.8	19.6	1.82	0.281	16.2
W_{23}	34.6	14.8	3.17	0.153	19.8
W_{24}	44.5	29.2	2.34	0.128	15.3
W_{25}	24.6	7.6	1.08	0.588	17.0
W_{26}	19.0	9.2	1.08	0.435	9.8
W_{27}	44.2	27.6	2.82	0.435	16.6
W_{28}	33.2	18.4	1.39	0.512	14.8
W_{29}	14.6	12.2	1.95	0.051	2.4
W_{30}	15.8	11.4	0.91	0.128	4.4
W_{31}	46.2	30.0	2.69	0.512	16.2
W_{32}	40.6	24.0	1.79	0.512	16.6
W_{33}	24.9	13.9	1.65	0.184	11.0
W_{34}	36.0	24.2	1.73	0.235	11.8
W_{35}	16.8	13.6	2.39	0.316	3.2
W_{36}	10.6	7.0	2.65	0.512	3.6
W_{37}	12.4	10.0	1.82	0.512	2.4
W_{38}	19.8	16.6	2.78	0.128	3.2
W_{39}	22.4	18.0	1.67	0.490	4.4
W_{40}	17.2	14.8	1.97	0.180	2.2
MEAN	**23.3**	**13.1**	**1.83**	**0.239**	**10.2**
RANGE	**8.4-46.2**	**5.4-30.0**	**0.56-3.87**	**0.025-0.793**	**1.8-24.0**
S.D$\pm$	**10.3**	**6.89**	**0.78**	**0.193**	**6.29**
C.V(%)	**44.2**	**52.4**	**42.6**	**80.6**	**61.6**

Appendix 11: Status of irrigation water quality parameters and index

Sample No.	SAR	PI	KR	SSP	RSC	IWQI
W_1	0.36	12.45	0.05	27.88	-21.4	250.9
W_2	0.73	33.23	0.17	68.18	-5.2	86.70
W_3	0.34	16.65	0.06	42.52	-12.8	134.1
W_4	1.44	35.18	0.30	53.50	-8.2	107.2
W_5	0.19	8.72	0.02	27.60	-24.0	215.4
W_6	0.68	16.89	0.11	35.29	-16.6	196.0
W_7	0.21	10.83	0.03	31.94	-20.2	205.0
W_8	0.58	18.43	0.10	41.79	-14.2	185.7
W_9	0.66	18.09	0.10	34.16	-16.7	198.6
W_{10}	0.51	11.18	0.06	21.94	-29.6	256.1
W_{11}	0.17	12.21	0.02	35.38	-16.8	197.6
W_{12}	0.23	9.96	0.03	26.25	-24.6	257.3
W_{13}	0.39	9.42	0.05	24.10	-27.6	293.7
W_{14}	1.31	24.84	0.22	34.79	-15.4	285.8
W_{15}	0.44	18.96	0.08	54.49	-10.6	163.0
W_{16}	0.89	28.35	0.17	48.37	-8.8	130.7
W_{17}	0.49	22.86	0.09	53.29	-9.0	148.7
W_{18}	0.22	8.24	0.02	23.61	-30.4	257.4
W_{19}	0.44	13.10	0.06	35.08	-18.6	200.2
W_{20}	1.18	37.88	0.28	65.55	-5.6	116.1
W_{21}	0.91	20.98	0.15	36.16	-15.4	235.0
W_{22}	0.43	9.73	0.05	19.93	-32.4	315.7
W_{23}	0.76	13.12	0.09	19.06	-31.4	344.5
W_{24}	0.49	8.81	0.05	16.43	-41.3	420.2
W_{25}	0.30	11.99	0.04	28.42	-20.6	233.1
W_{26}	0.35	16.28	0.05	35.85	-14.2	188.0
W_{27}	0.59	10.45	0.06	14.88	-39.8	504.6
W_{28}	0.34	7.89	0.04	20.81	-31.4	243.9
W_{29}	0.72	19.88	0.13	49.54	-12.8	233.5
W_{30}	0.32	14.71	0.05	49.07	-13.4	165.9
W_{31}	0.55	8.53	0.05	15.54	-44.0	346.4
W_{32}	0.39	7.55	0.04	18.40	-38.6	263.5
W_{33}	0.46	12.73	0.06	28.24	-21.9	374.5
W_{34}	0.40	9.88	0.04	21.99	-32.0	331.7
W_{35}	0.82	24.33	0.14	42.73	-11.6	335.5
W_{36}	1.15	34.71	0.25	61.88	-6.80	156.8
W_{37}	0.73	26.50	0.14	49.92	-8.60	180.3
W_{38}	0.88	17.91	0.14	31.88	-18.2	202.2
W_{39}	0.49	12.51	0.07	32.40	-20.6	325.2
W_{40}	0.67	17.65	0.11	38.60	-15.2	181.3
MEAN	**0.58**	**16.84**	**0.09**	**35.44**	**-20.16**	**236.7**
RANGE	**0.17-1.44**	**7.55-37.88**	**0.02-0.30**	**14.88-68.18**	**-44 - -5.2**	**86.7-504.6**
S.D±	**0.30**	**8.27**	**0.07**	**14.11**	**10.4**	**88.9**
C.V (%)	**52.6**	**49.10**	**72.2**	**39.81**	**-51.5**	**37.5**

NOTE: SAR= Sodium Adsorption Ratio, RSC= Residual Sodium Carbonate, KR= Kelly's Ratio, SSP= Soluble Sodium Percentage, PI= Permeability Index, IWQI= Irrigation Water Quality Index.